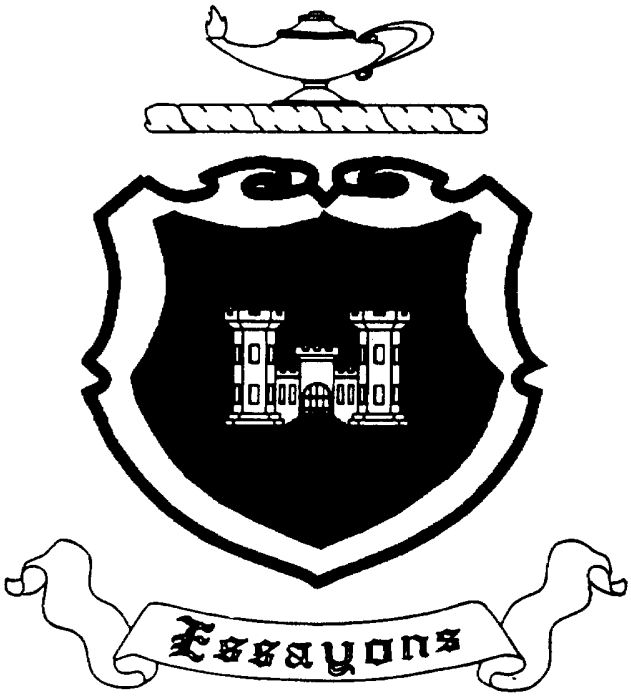
SUBCOURSE
EN0562

EDITION
A

US ARMY ENGINEER CENTER AND SCHOOL

PAINTING I



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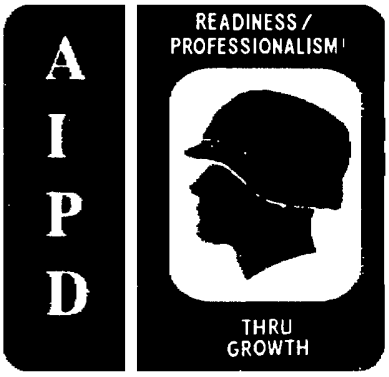

PAINTING I

Subcourse EN 0562

EDITION A

United States Army Engineer School
Fort Leonard Wood, Missouri 65473

10 Credit Hours

Edition Date: April 1998

SUBCOURSE OVERVIEW

This subcourse is the first of two subcourses on the subject of painting. It begins with a review of those aspects of safety practice that are of continuous importance to you, the painter. This is followed by instruction on the selection and mixing of paints, the operation and maintenance of paint equipment, and the proper storage of paint supplies. In addition, a lesson is devoted to the identification of metals and to the methods employed to detect and prevent corrosion. This subcourse consists of five lessons, each corresponding to a terminal learning objective as indicated below.

Work must be accomplished in a manner consistent with environmental laws and regulations.

There are no prerequisites for this subcourse.

The lessons in this subcourse reflect the doctrine which was current at the time it was prepared. In your own work situation, always refer to the latest official publications.

Unless otherwise stated, the masculine gender of singular pronouns is used to refer to both men and women.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will learn to identify painting processes, products, and safety practices.

CONDITION: You will be given the material contained in this subcourse.
STANDARD: To demonstrate proficiency of this task, you must achieve a minimum of 70 percent on the subcourse examination.

TABLE OF CONTENTS

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LESSON 1

SAFETY

OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn basic safety procedures associated with paint materials and equipment and learn to explain the safety measures that prevent accidents.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will learn to describe safety procedures and guidelines to be followed when painting.

CONDITION: You will be given the material contained in this lesson.

STANDARD: You must complete the lesson and the practice exercise.

REFERENCES: The material contained in this lesson was derived from the TM 5-800 series, TM 5-618, EMs 385-1-1 and 1110-2-3400, TB MED 502, AFI 48-101, AFP 127-1 Vols 1 and 3, OPNAVINST 5100.23D, AFJI 48-107, TO 00-25-232, MIL-STD 1212, and NFPA 101.

INTRODUCTION

Everyone has the responsibility of being safety conscious on each and every type of job that they encounter. You, as the painting foreman, must ensure that each individual exposed to painting projects is made aware of the dangers involved in this field. Painting is not an assigned specific military occupation specialty (MOS), but it is normally a duty assumed by various personnel with a wide background of experience in construction. You must be familiar with the safety shortcomings that you and your personnel may encounter on any job.

PART A: GENERAL HAZARDS

1-1. Hazards. Every painting assignment exposes your maintenance personnel to conditions and situations that represent actual or potential danger to themselves and to others in the area. A potential hazard is always present through the frequent use of toxic and flammable materials, pressurized equipment, ladders, scaffolds, and rigging. Hazards may also be inherent in the very nature of the environment or caused through the ignorance or carelessness of operators. It is extremely important that you are aware of all

potential hazards, since continuous and automatic precautionary measures will minimize the problem and improve both the efficiency and the morale of your painting crew.

a. Paint Materials. Most paint materials are hazardous to some degree. All paints, except water-based paints, are flammable; many are toxic; and others can irritate the skin. If simple precautions are followed by personnel, however, most paints are quite safe.

b. Surface-Preparation Materials. Painting often requires the use of solvent, acid, or alkali cleaners for surface preparation. All of these will harm your skin unless you use them with care. Paint removers are also very irritating to the skin. The use of high-pressure abrasives or water-blasting methods may expose you to hazards. Pressures as low as 10 to 15 pounds per square inch have been known to cause serious injuries. In addition, carelessness during the use of abrasive-blasting operations may result in lung disease after continued exposure. Steam-cleaning procedures employ high heat and pressure; both are very hazardous to the operator and personnel nearby if you do not follow safety procedures and handle the equipment properly.

c. Equipment. Ladders, scaffolds, and rigging must be used by painters for areas that are not readily accessible from the floor or ground. Pressure equipment is used to prepare surfaces and to apply paint. All of this equipment can be extremely hazardous if you handle it carelessly. Your actual operation time of this equipment may be less than the time required to prepare it for use; nevertheless, you should not omit precautions on the basis that risk decreases in proportion to the time operated.

d. Environment. Painting conditions will vary from job to job. One obviously hazardous location is the interior of a tank. However, painting the interior of a small room or closet may be more hazardous, since there is often no special precautions taken and inadequate ventilation may be provided. Furthermore, your painting personnel may encounter other hazards that exist in the area in which they are working in addition to the hazards inherent in the painting operation. For example, slippery floors or obstacles located on the floor may cause falls. Electrical or mechanical equipment may produce shocks or other serious injuries. Uninsulated steam lines or hot pipes may cause severe burns or too rapid evaporation of solvent, thus creating a toxic hazard.

e. Painting Crew. A potential threat to the safety of your crew and others in the painting area is painting personnel who lack training, experience, or knowledge of the hazards involved. An element of risk is present even when well-trained workers follow all of the prescribed safety procedures. Taking proper precautions will reduce this risk to a minimum, but no safeguard can guarantee protection against ignorance. Careless performance by even a trained painter will also increase hazards tremendously. Deviating from established procedures by taking shortcuts will often produce unsafe working conditions. This practice may result in accidents with the consequential loss of time and materials, and of greatest concern, human suffering.

f. Degree of Hazard. The risks involved vary from job to job. Painting the interior of a home with water-based paints, for example, is much less hazardous than painting a water tank 100 feet above the ground. You, as the foreman, must be responsible for taking the special precautions necessary, designating the equipment required, and advising your crew of the specific hazards for each job. Though hazards in jobs may vary in degrees, you

should never forget that they do exist in every job. You and your painting personnel increase the odds that accidents will occur when you ignore hazards in any job. Regardless of the degree of hazard that may be present, relaxation of precautions in one job will inevitably lead to carelessness in all jobs. The careless habits that are formed will eventually result in an unnecessary increase in the accident rate.

1-2. Safety Measures. You must have a continual enforced safety program due to the potential hazards present in all painting operations. Adequate safety procedures will provide protection against the three major types of hazards; namely, accidents, fire, and those to health. All personnel must be thoroughly familiar with safety rules. Each worker is responsible for adhering to all established precautionary programs for his own protection as well as that of others. The practice of disregarding safety measures will increase potential dangers and the odds that an accident will occur. For additional information, see OPNAVINST 5100.23D and MIL-STD 1212.

a. General Health. All of your personnel should be in good health. Painters who are sensitive to skin-irritating materials should only work with nonsensitive paint materials, such as water-based paints. Any worker sensitive to heights should not work on ladders, scaffolds, or rigging. Personnel who have an improper attitude toward safety should not be allowed in painting crews.

b. Environment. Always study the working environment before you send painters into any work area. Look for hazards, such as poor ventilation and noxious fumes. Before you allow a painter to enter such an area, you must ensure that he is protected by devices that will allow him to work in safety. If ventilation is required, then provide outside air at a minimum rate of 15 cubic feet of air per minute per person or 1 1/2 changes per hour, whichever is greater. Otherwise, provide respiratory protective equipment. If exhaust systems are used, such as in a tank, the system must take suction from the bottom of the tank or a similar area in which the work is being done. Never allow a painter to work alone in a hazardous area (see para 1-2c[5]). The discharge from exhaust systems must be arranged so that contaminated air will not create a health hazard in surrounding areas. Temperatures should be kept at 65 to 75 degrees (°) Fahrenheit (F), if possible.

c. Forms of Protection. Common forms of protection are respiratory devices, safety helmets, eye protection, protective clothing, and the use of a buddy system.

(1) Respiratory protection. Your personnel must wear the proper type of face mask in hazardous areas. All respirators must be devices approved by the US Bureau of Mines. The most important types of respirators are as follows:

(a) Dispersoid-filter respirators. The respirators (Figure 1-1, page 1-4) are worn for protection against dusts that are present when sanding. The respirators contain filters only.

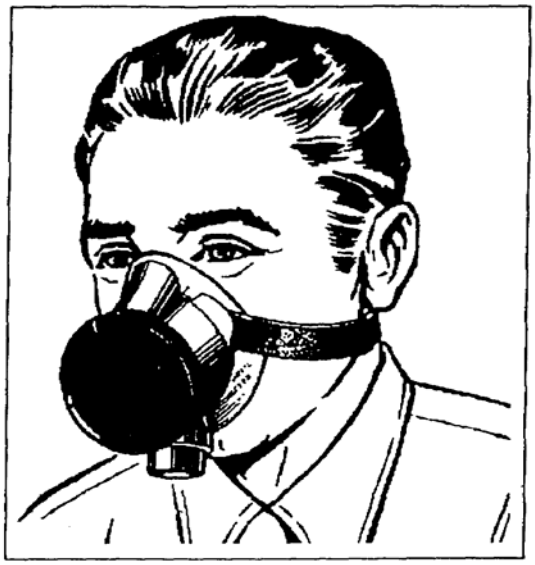

Figure 1-1. Dispersoid-filter respirator

(b) Chemical-cartridge respirators. The respirators (Figure 1-2) are used for protection against fumes and solvent vapors. The respirators contain activated-carbon cartridges that absorb fumes or vapors.

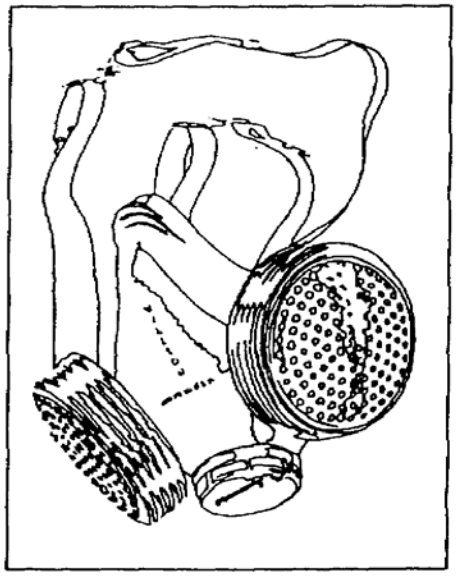

Figure 1-2. Chemical-cartridge respirator

For additional information on respirators, refer to TB MED 502, AFI 48-101, and OPNAVINST 5100.23D. The life or health of your personnel may depend on the availability and proper functioning of respiratory equipment. Clean respirators immediately after use, and maintain and store them in clean, dry compartments. Inspect

filters, cartridges, and rubber parts before each use and at regular intervals for any signs of deterioration. Always replace any suspect filter or cartridge immediately.

(2) Safety helmets. Abrasive-blasting helmets (Figure 1-3) are used when you are blast-cleaning surfaces that will be painted.

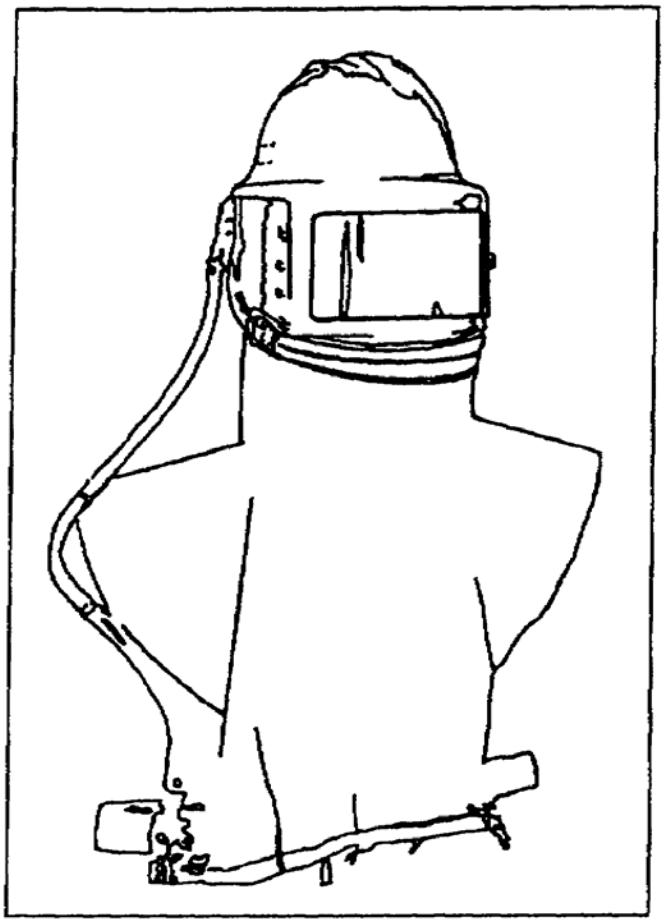

Figure 1-3. Abrasive-blasting helmet

(3) Eye protection. Protect eyes by wearing safety goggles (Figure 1-4, page 1-6) in areas where there is any possibility of dust, fumes, or solvents touching the eyes as may occur when blasting, sanding, or spraying. Keep eye-protection items clean and readily available. They should fit well, contain lenses of unbreakable glass or plastic, and allow adequate peripheral as well as straight-ahead vision.

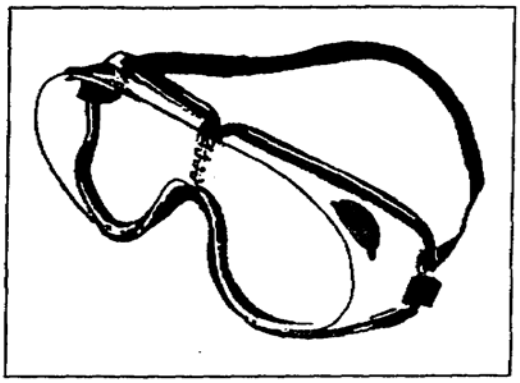

Figure 1-4. Safety goggles

(4) Protective clothing. The following safety rules apply to protective clothing. You should-

- Wear clean clothing that covers you as much as possible to avoid skin contact with painting or cleaning materials.
- Wear clothing that is safe for work conditions. Clothing with cuffs, tears, rips, or loose pockets; loose ties; and jewelry are potential causes of accidents.
- Wear safety helmets when using abrasive-blasting media.
- Wear hard hats and steel-toed safety shoes wherever there is any possibility of danger from falling objects.
- Wear shoes that have nonskid rubber soles when working in enclosed spaces or where flammable vapors may be present.
- Wear acid-proof clothing when handling acid cleaners.
- Wear acid-proof air-supplied suits when using acid cleaning materials in enclosed areas.

(5) Buddy system. Personnel should never work alone in hazardous areas. Assign at least two men to such jobs, and ensure that each is visible to the other at all times during the painting operation. Then, if one should have an accident, the other can immediately come to his aid.

1-3. Responsibilities of the Foreman. As the foreman, you should lay out the work and manage projects in such a manner as to produce the safest possible conditions. The safety of personnel is one of your prime responsibilities. To ensure safe working conditions, use a safety checklist (Figure 1-5) before a job gets underway.

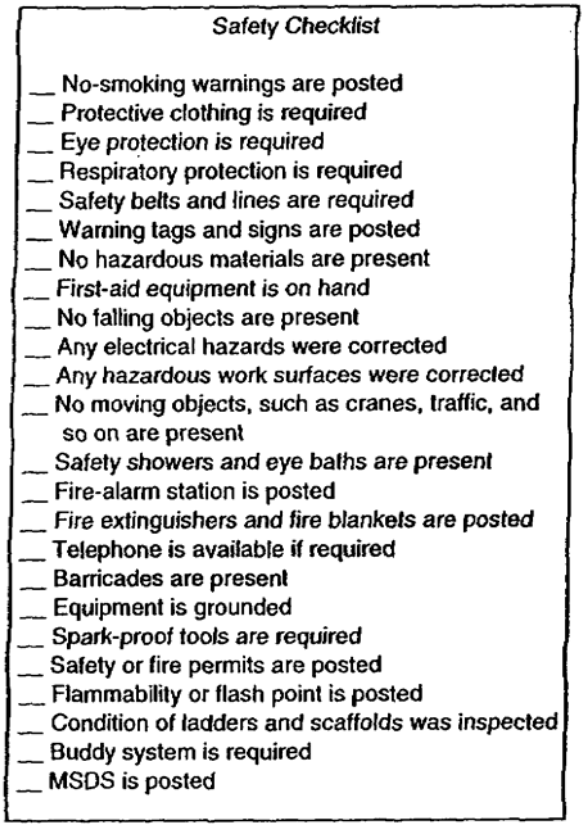

Figure 1-5. Safety checklist

In addition to the safety checklist, adhere to the following safety rules:

- Ensure that there is awareness of potential hazards in the work area.
- Ensure that each painter understands and accepts his personal responsibility for safety and that he is informed of all safety rules.
- Ensure that all safety measures take place each day before any job is started.
- Insist that your men work safely. Use disciplinary action in accordance with existing personnel directives, if necessary.
- Ensure that all equipment meets the safety standards. Use nonsparking tools in hazardous areas. Anticipate possible risks with new types of equipment, and secure expert advice on potential hazards in advance.
- Encourage your men to discuss the hazards of their work. No job should proceed if any question about safety remains unanswered. Be receptive to their ideas and suggestions; these may be the best source of field experience that will prevent accidents.
- Set a good example for your men by demonstrating safety in your personal work and conduct.

PART B: ACCIDENT, FIRE, AND HEALTH HAZARDS

1-4. Accident Hazards. Paint operation accidents are caused by unsafe working equipment, unsafe working conditions, and careless personnel. Accidents can be caused by personnel who-

- Lack knowledge, experience, and training in the use of painting materials and equipment.
- Maintain and store equipment improperly.
- Fail to precheck equipment for mechanical and structural flaws.
- Use equipment improperly.
- Fail to consider environmental conditions and existing hazards in work areas before, during, and after painting operations.
- Perform carelessly.

Accidents most frequently involve commonly used equipment. The most common and most serious accidents, by far, are falls either from a height or on the ground because of a loss of footing. Falling or moving objects are the next most serious hazard.

1-5. Precautions and Prevention. You should take nothing for granted. The proper use of equipment must be taught by qualified operators to all of your personnel. Regularly schedule refresher courses on the use of all equipment.

1-6. Equipment Check and Use. Enforcement of the following basic procedures in setting up and using equipment is imperative to assuring safety standards and maximum protection of all personnel.

a. Ladders. The following safety rules apply to ladders:

(1) Storage. When storing wood ladders you should-

- Protect them from the weather and the ground by storing them in warm, dry structures.
- Protect them with clear coatings only so that cracks, splinters, or other defects will be readily visible.

(2) Use. When placing or using ladders you should-

- Inspect all ladders frequently for loose or bent parts, cracks, breaks, or splinters.
- Use safety shoes on all straight and extension ladders. When metal ladders are used, shoes should be made of insulating material (Figure 1-6).

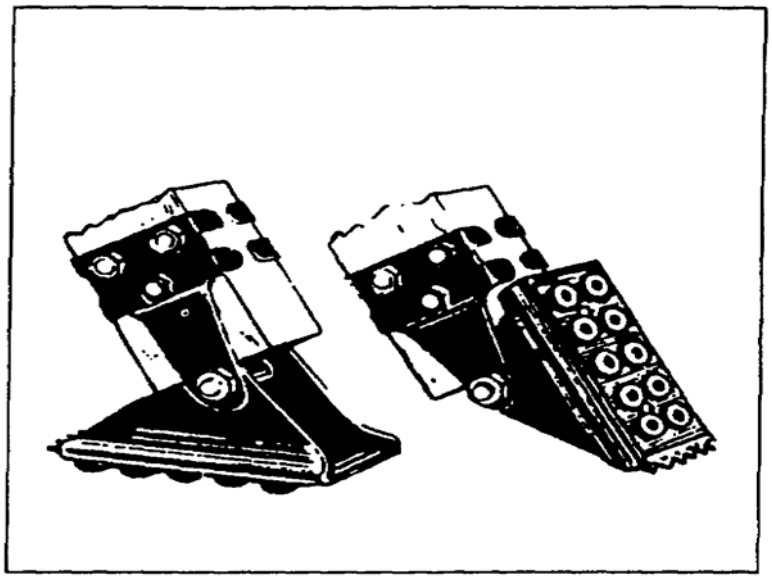

Figure 1-6. Ladder safety shoes

- Use only portable ladders that can be readily carried and placed by two men. Use the correct length of ladder; never splice ladders to form a longer ladder.

- Pretest all ladders and scaffolds before use by placing them horizontally, with blocks under ends, and bouncing in the center or walking along the ladder or scaffold.

- Use stepladders that are 10 feet or less in height. Avoid using stepladders as a straight ladder or standing on the top platform of ladders.

- Rope off all doorways in front of the ladder and place warning signs. Use hand lines to raise or lower tools and materials. Avoid reaching out from the ladder in any direction; instead, move the ladder as the work requires.

- Avoid using metal ladders in areas where contact with electric power lines is possible.

- Use extension ladders that have a minimum overlap of 15 percent for each section (Figure 1-7, page 1-10).

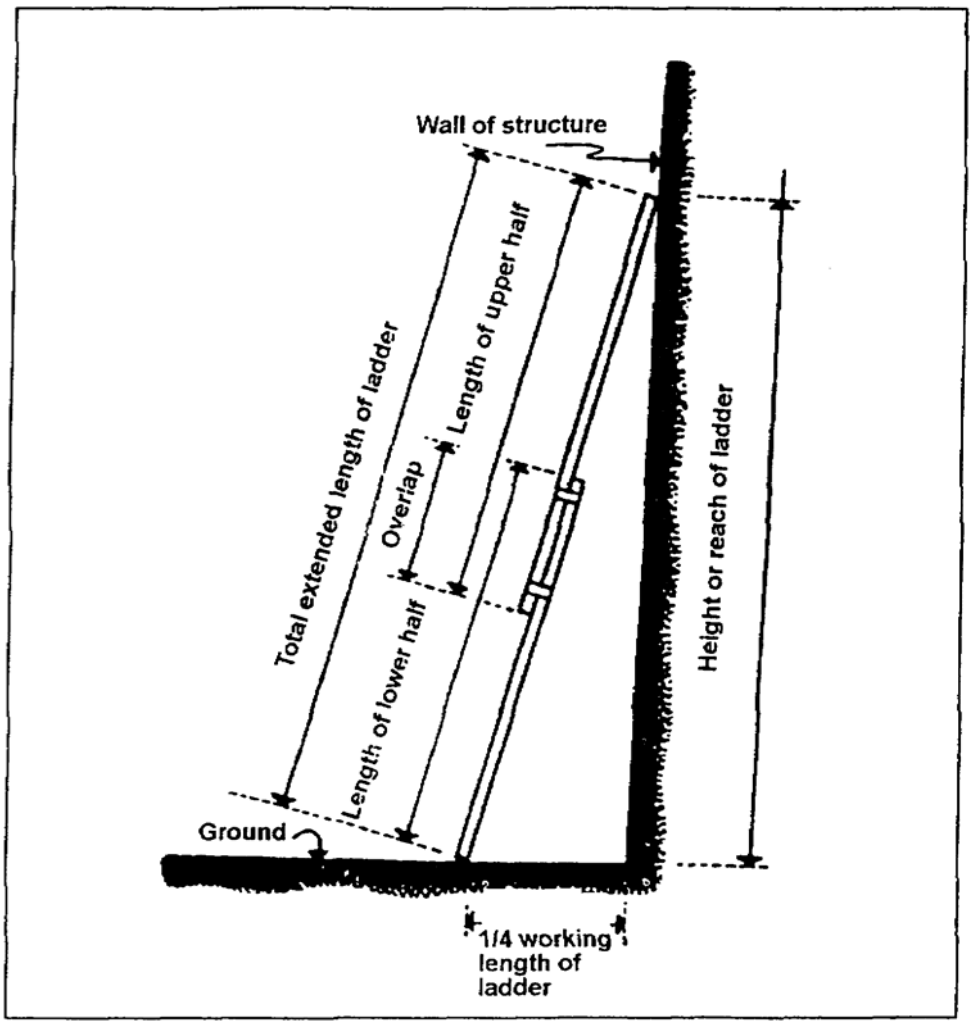

Figure 1-7. Ladder stability

- Place ladders so that the horizontal distance from the support structure to the ladder foot is at least one-fourth of the working length as shown in Figure 1-7. Be sure that the ladder is securely in place.

b. Scaffolds (Figures 1-8 through 1-15, pages 1-12 through 1-18). The following safety rules apply to scaffolds and planking:

(1) Scaffolds. When setting up or using scaffolds, you should--

- Inspect all parts before use. Reject metal parts that are damaged by corrosion, and reject wood parts with defects, such as checks, splits, unsound knots, or decay.

- Provide adequate sills or underpinnings when erecting scaffolds on filled or soft ground. Be sure that scaffolds are plumb and level. Compensate for unevenness of the ground by blocking or using adjusting screws.

- Anchor scaffolds to the wall about every 28 feet in length and 18 feet in height. Do not force braces to fit. Use horizontal and diagonal-bracing at the bottom and at every 30 feet in height.

- Use straight-grained lumber. Drive all nails flush with the lumber so that nails are not subject to direct pull.

- Provide guardrails, regardless of working height, on the full length of the scaffold and also on the ends.

- Erect scaffolds so that ladders are lined up from top to bottom.

- Use ladders when climbing scaffolds.

- Use tubular-pole scaffolds made of 2-inch, olive drab galvanized steel tubing or other corrosion-resistant metal of equal strength. Use only experienced personnel to erect and dismantle them.

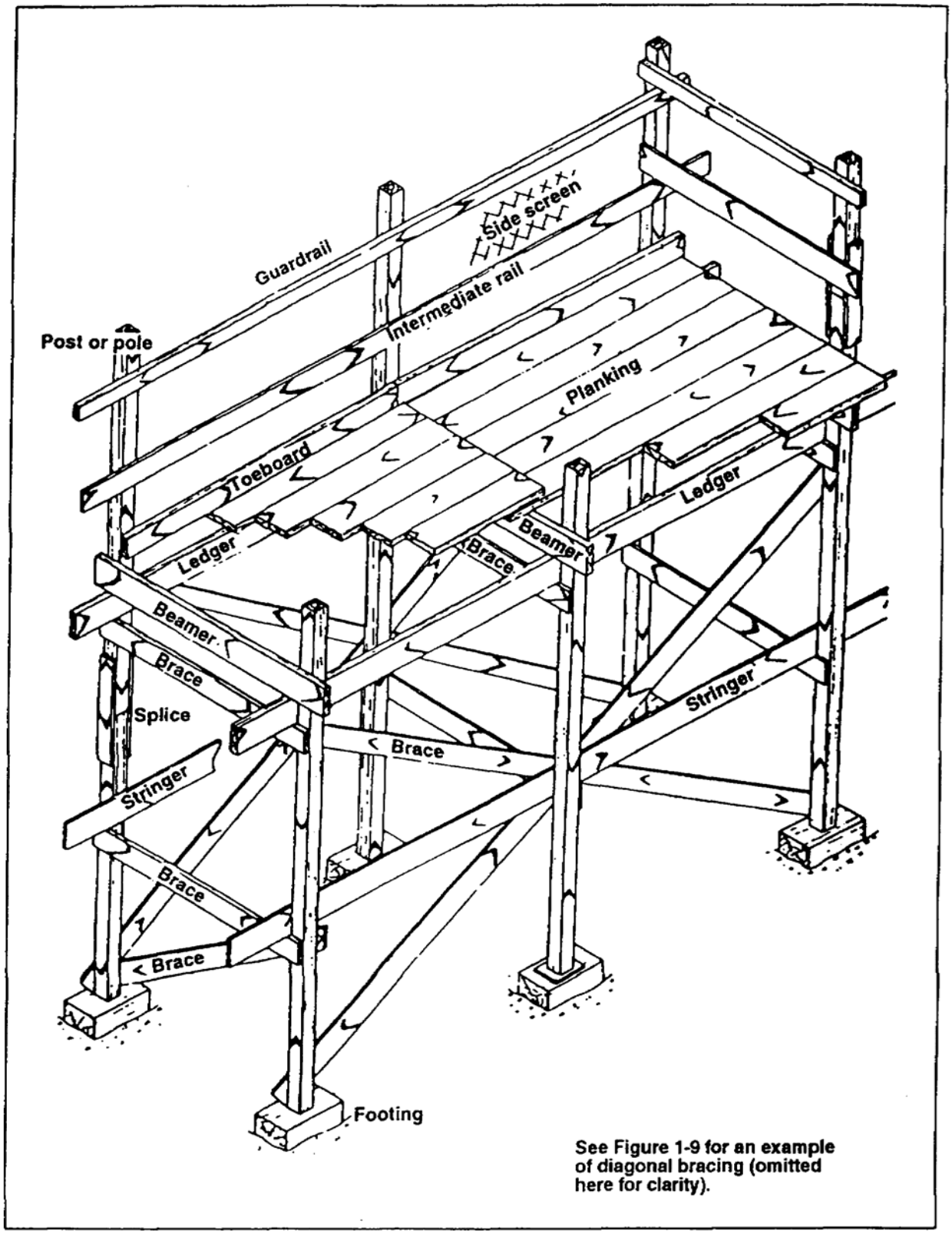

Figure 1-8. Double-pole or independent scaffold

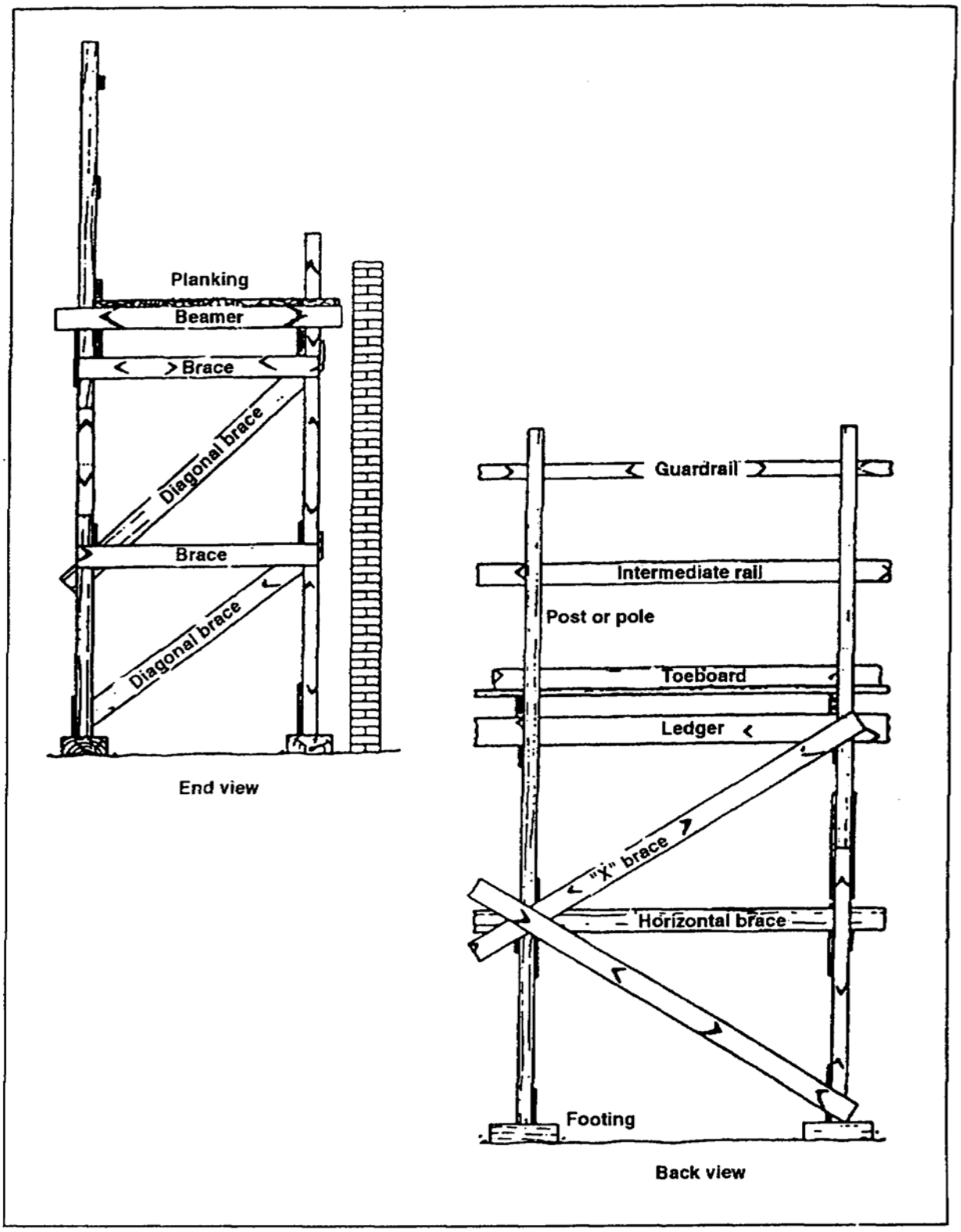

Figure 1-9. Diagonal bracing on double-pole scaffold

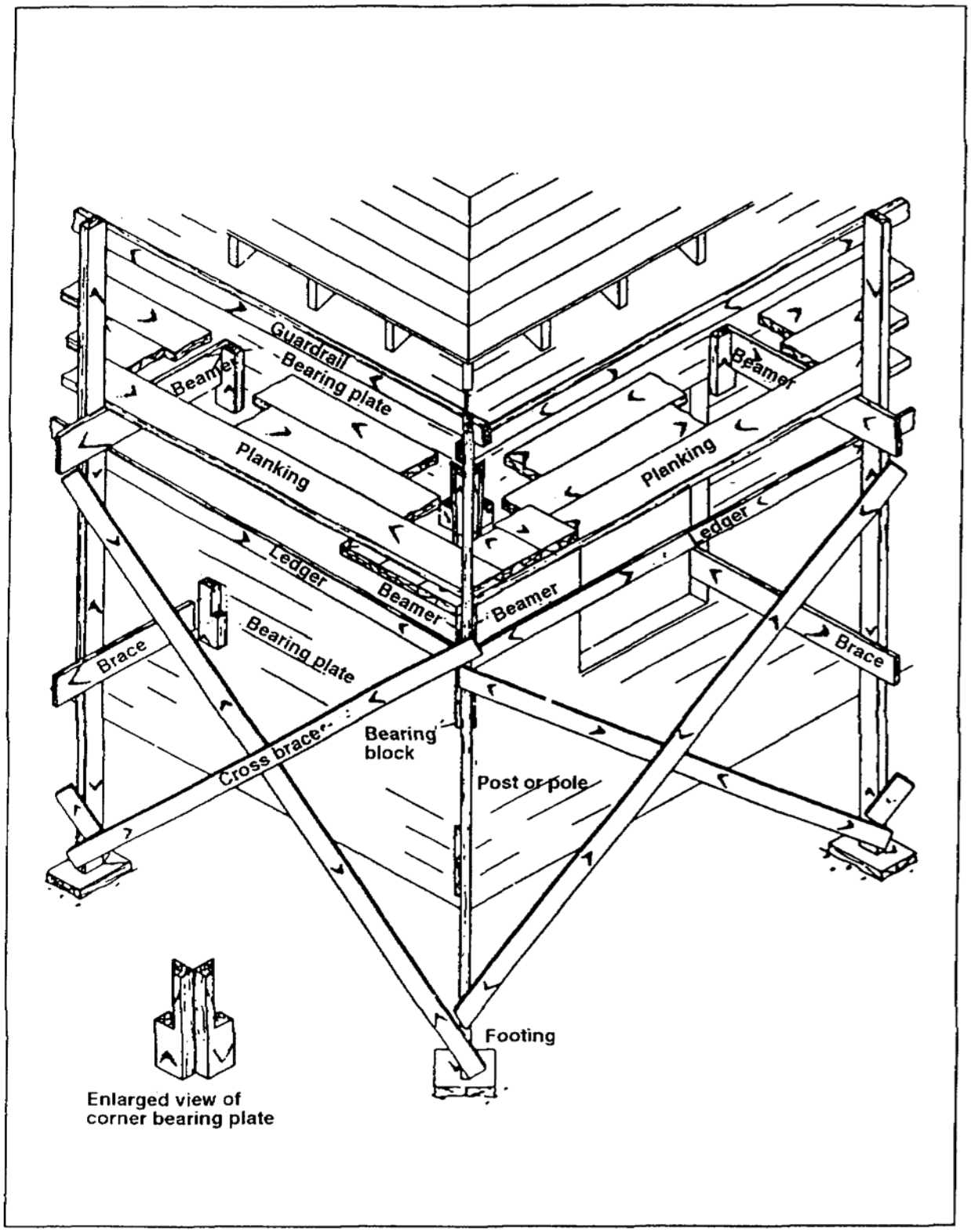

Figure 1-10. Single-pole scaffold corner construction

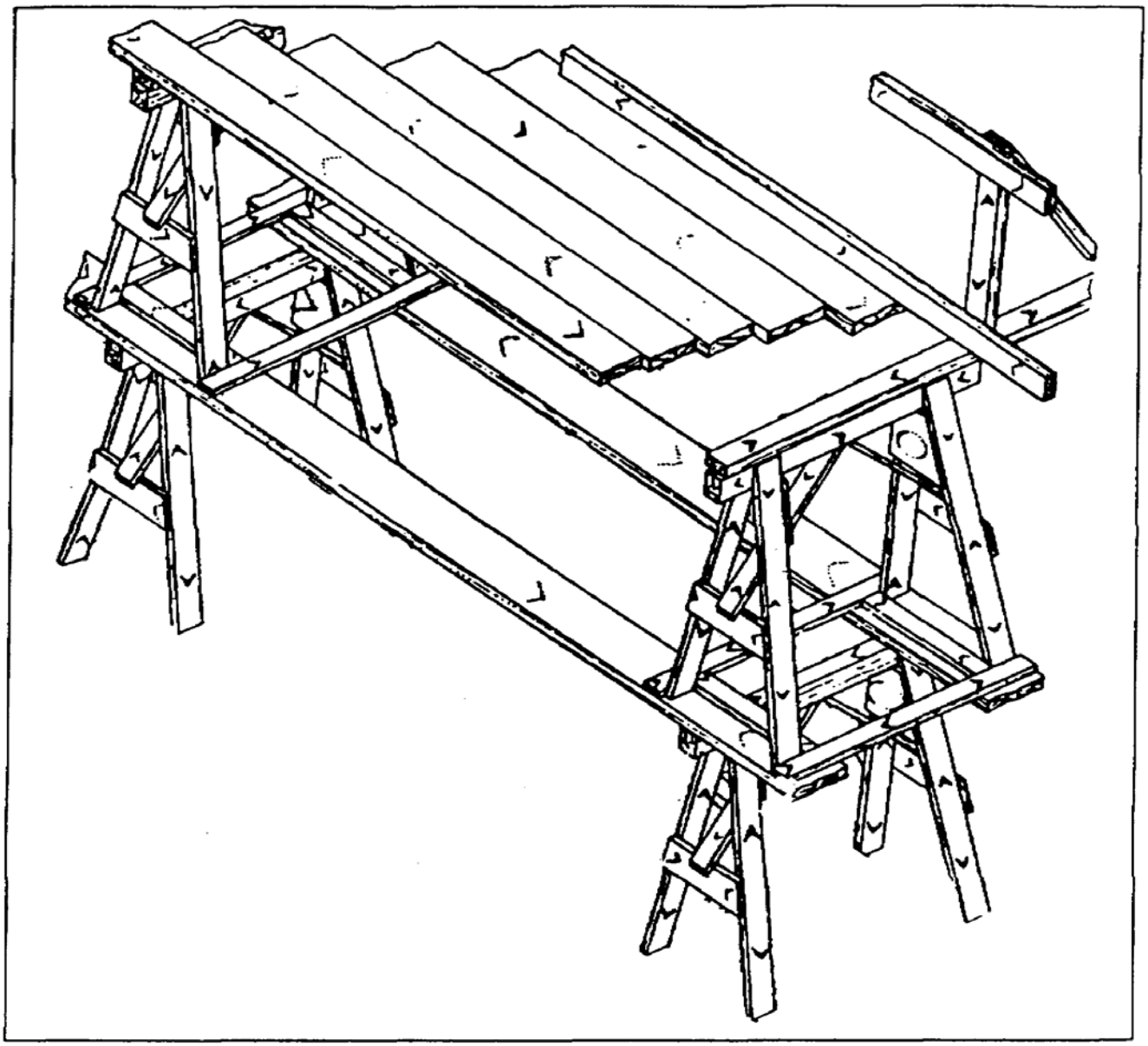

Figure 1-11. Horse scaffold, two tiers (maximum height two tiers or 10 feet)

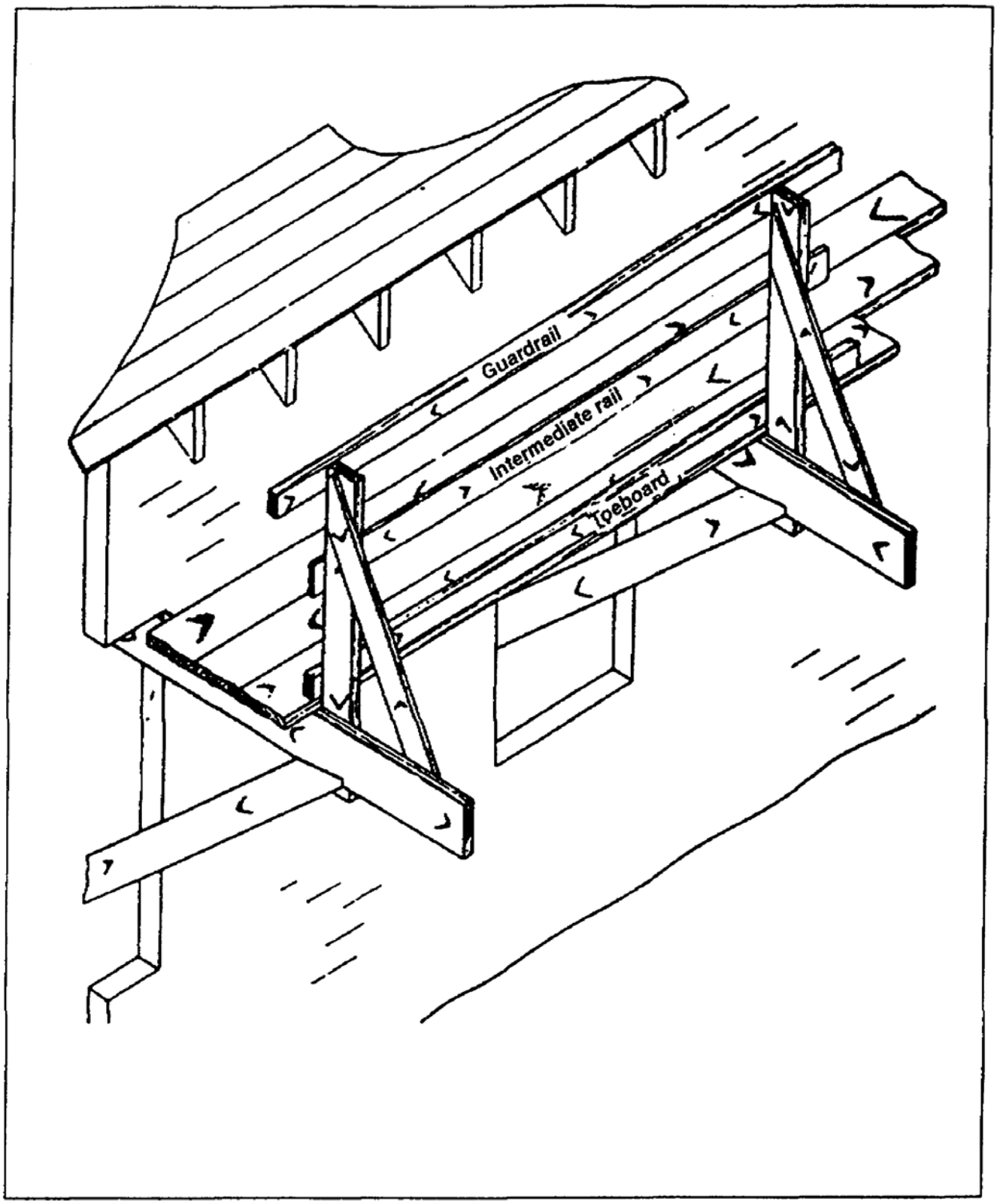

Figure 1-12. Outrigger scaffold with guardrail

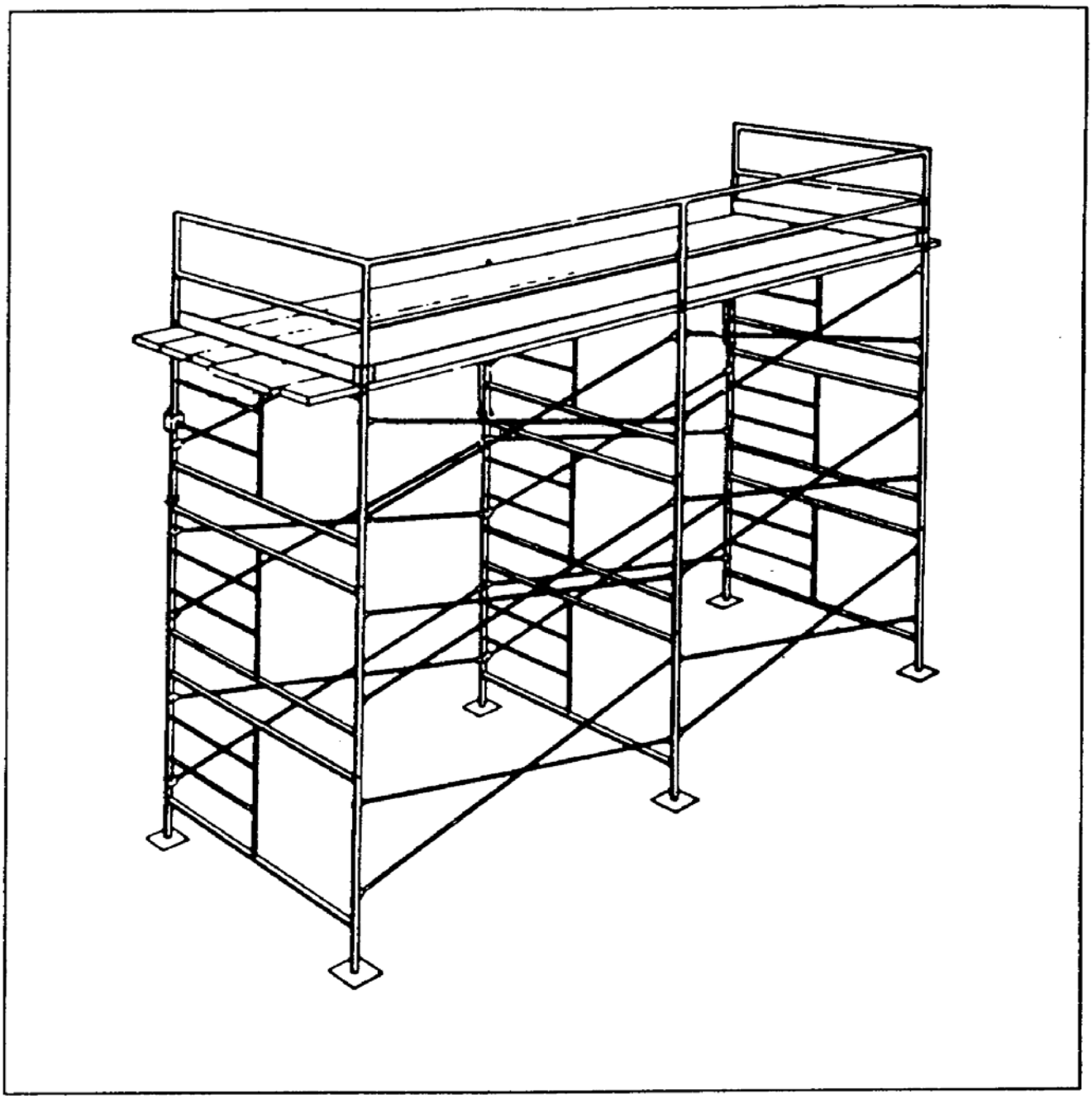

Figure 1-13. Pipe scaffold

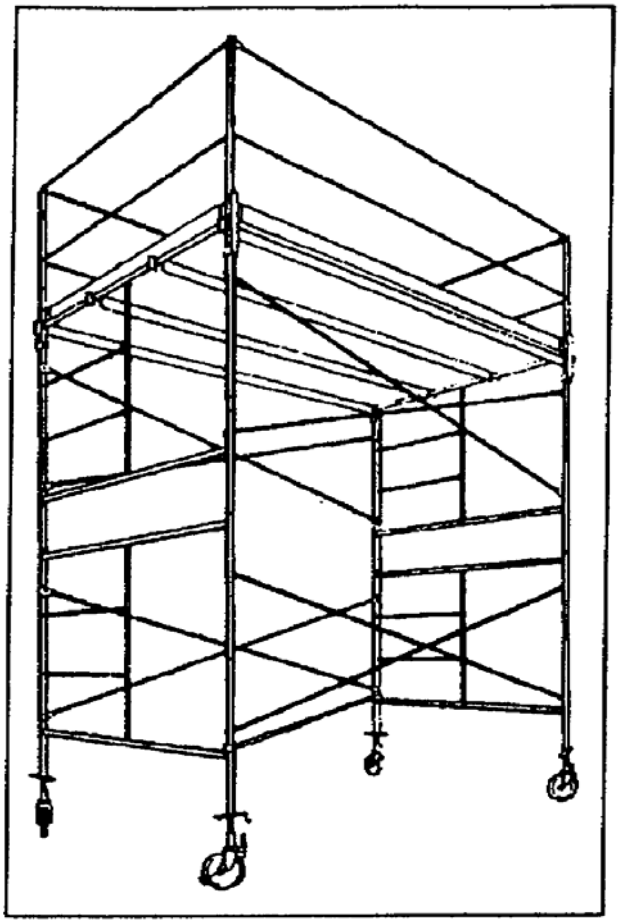

Figure 1-14. Pipe scaffold (roller-outrigging type)

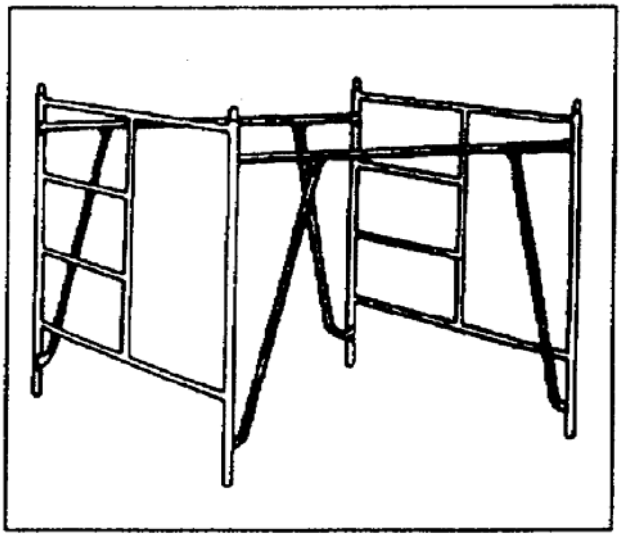

Figure 1-15. Welded pipe scaffold with straddle braces

(2) Planking. To determine the nominal sizes of planking, use Table 1-1. When applying scaffold planking, you should-

- Use planking that has at least a 2-foot overlap. Secure planking well to the wood scaffold. Use planking of uniform thickness and lay it close together for platforms. Planking must overlap and be fastened at supports. Paint planking only at the ends to identify it and to deter its use for other purposes.

- Test scaffolds and extensible planking (extended to working length) by raising them 1 foot off the ground and loading them with weights at least four times the anticipated working load.

Table 1-1. Safe center loads for scaffold planking

Span (Feet)	Planking Sizes (Inches)*					
	2 by 8	2 by 10	2 by 12	3 by 8	3 by 10	3 by 12
	Load (Pounds)					
6	200	255	310	525	665	805
8	150	190	230	390	500	605
10	120	155	185	315	400	485
12	100	130	155	265	335	405
14	NA	110	135	225	285	346
16	NA	NA	115	195	250	305

*Dressed sizes of planking, reading left to right: 1 5/8 by 7 1/2, 1 5/8 by 9 1/2, 1 5/8 by 11, 2 5/8 by 7 1/2, 2 5/8 by 9 1/2, and 2 5/8 by 11 1/2.

Values given are—

- In pounds for loads at center and allows for the weight of planking.
- Planking supported at the ends, wide side of planking faceup, and loads concentrated at the center of the span.

Loads given are net and do not include the weight of the planking.

For loads uniformly distributed on the wide surface throughout the length, the safe loads may be twice those given. If you select any of the following for planking, increase the above loads by 25 percent:

- Coastal-region Douglas fir.
- Merchantable, longleaf southern pine.
- Dense (sound), square-edge southern pine.

c. Rolling Towers. The following safety rules apply to setting up and using rolling towers. You should-

- Inspect all tower parts before use. Do not use parts that are damaged by corrosion, deterioration, or misuse.

- Use a guy or tie off towers with heights that are more than three times the minimum base dimension, and fix towers at every 18 feet of elevation. Maintain the stability of towers over 25 feet high with outriggers or handling lines. Use horizontal and diagonal bracing at the bottom and at every height section.

- Provide unit lock arms on all towers. Do not use casters less than 6 inches in diameter. Do not extend adjusting screws more than 12 inches.

- Look where you are going when moving towers. Do not attempt to move a tower without sufficient help. Apply all caster brakes when the tower is stationary. Never ride towers.

d. Swinging Scaffolds and Boatswain's Chairs. The following safety rules apply to setting up and using swinging scaffolds and boatswain's chairs (Figures 1-16 through 1-18, pages 1-21 and 1-22). You should-

- Read instructions on the proper use and maintenance of the equipment.

- Follow prescribed load capacities.

- Use stages at least 27 inches wide and supply them with guardrails (not rope).

- Use only experienced personnel to erect or operate stages.

- Check ropes and blocks before use by suspending stages 1 foot off the ground and loading with at least four times the anticipated work load.

- Check for nearby electric power lines before locating on the job site.

- Use power stages that have free-fall safety devices with hand controls in case of power failure.

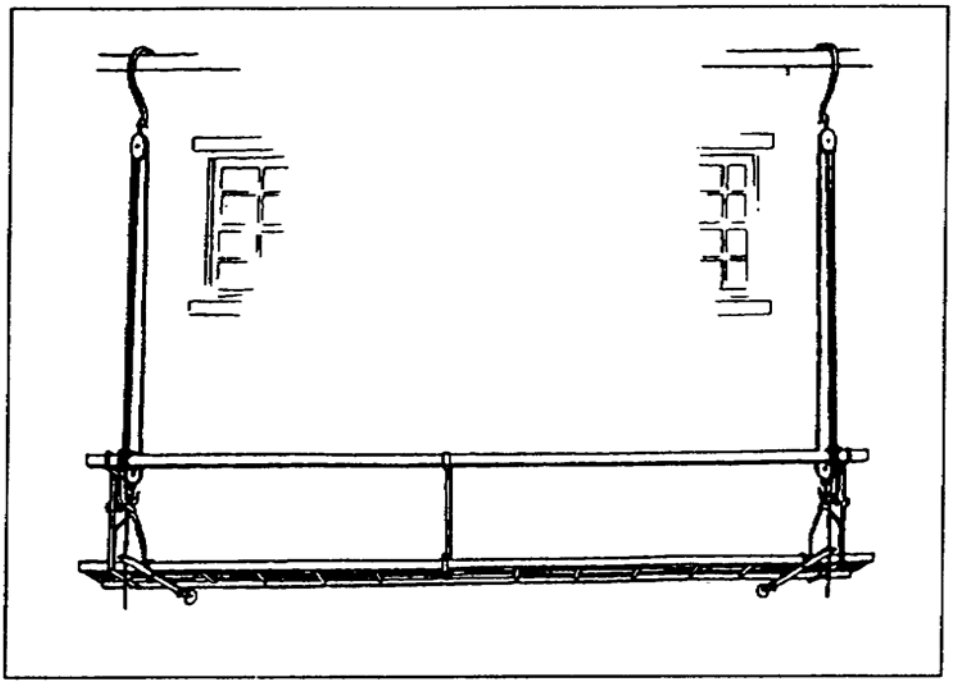

Figure 1-16. Swinging scaffold with ladder (platform type)

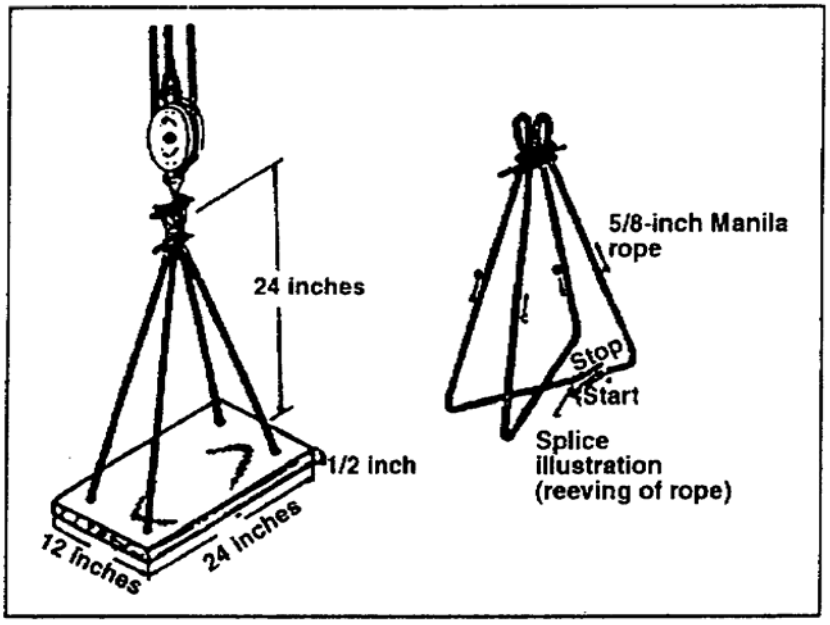

Figure 1-17. Boatswain's chair (construction details)

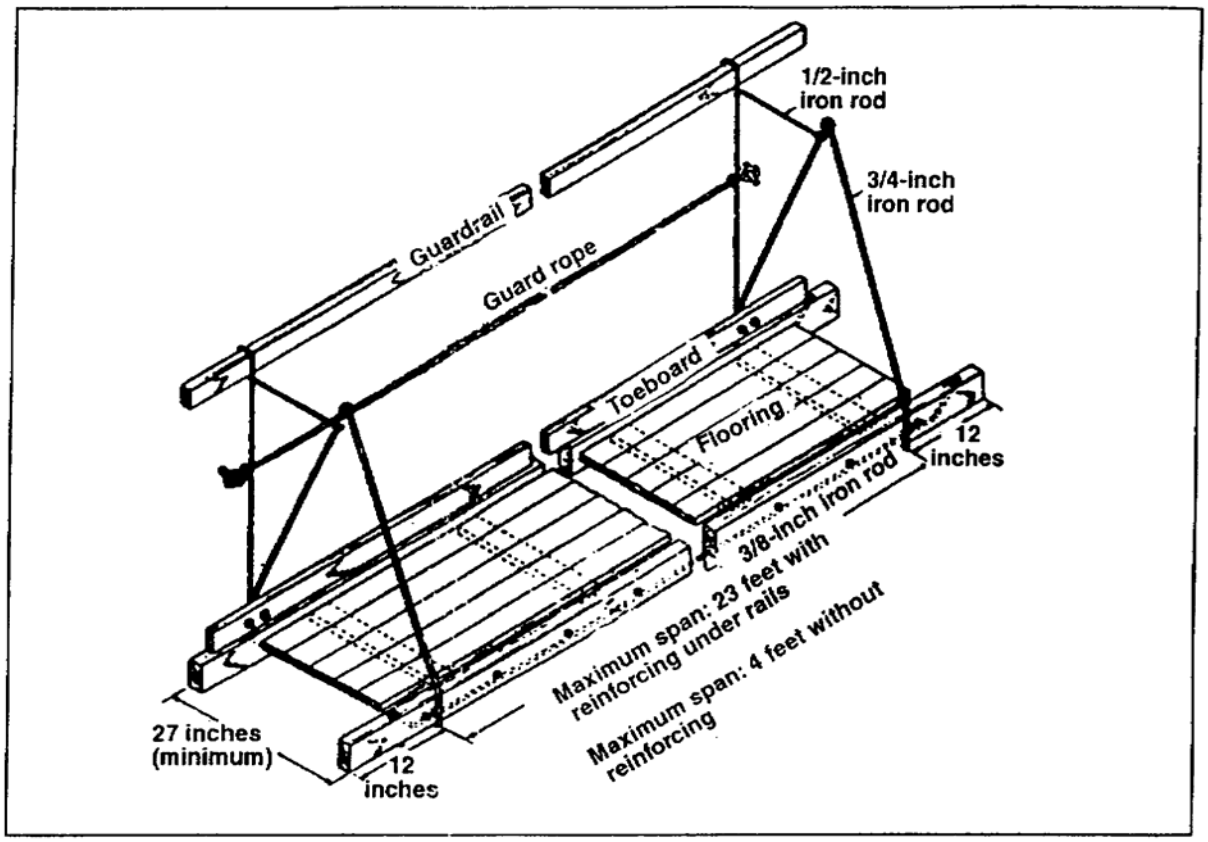

Figure 1-18. Swinging scaffold (construction details)

e. Ropes and Cables. The techniques and illustrated procedures for proper knots and hitches are covered in Lesson 4. The following safety rules apply to setting up and using ropes and cables. You should-

- Store ropes and cables (coiled) in dry, empty drums.
- Use wire rope that is at least 3/4 inch in diameter for platform slings. For boatswain's chairs and lifelines, use Manila rope that is at least 5/8 inch in diameter. Use proper clamps with wire rope and use proper knots and hitches with Manila rope. Inspect ropes frequently. Discard ropes if they are exposed to acid or excessive heat. Check for dry rot, brittleness, or excessive wear. Never use frozen rope.
- Inspect all wire ropes and cables frequently in accordance with current service safety criteria.
- Do not attempt to salvage rope or cable by splicing.

f. Pressurized Equipment. The following safety rules apply to all types of equipment used for spraying or blasting. You should-

- Use only approved equipment. Use remote-controlled deadman valves on high-pressure equipment (60 pounds or higher). Valves should be activated by the same air used for blasting or spraying.

- Conduct a hydrostatic test at least once, preferably twice, a year.

- Test safety relief valves daily.

- Use a conductive hose. Ground nozzles, tanks, and pressure equipment when in use. The object being sprayed should also be grounded (Figures 1-19 and 1-20).

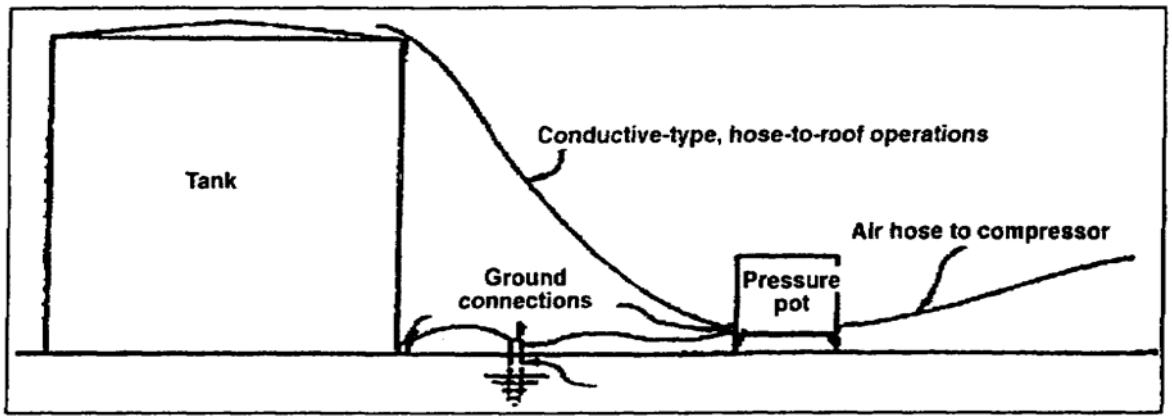

Figure 1-19. Grounding of tank and equipment

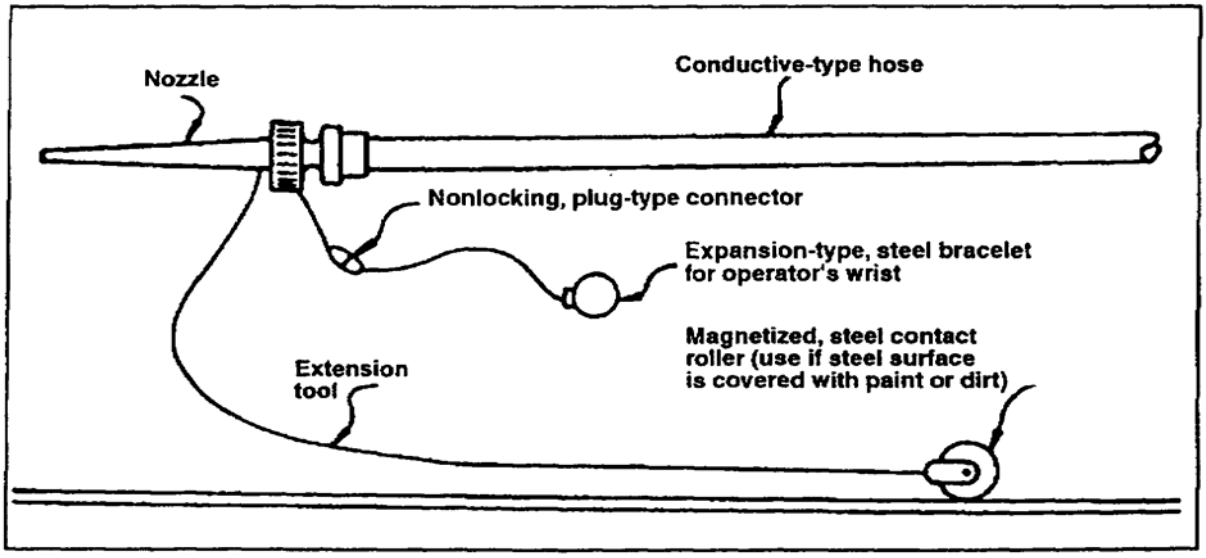

Figure 1-20. Grounding of blast nozzle

- Store hoses in dry areas.

- Avoid sharp bends (especially when curved around an object) when the hose is used. Secure high-pressure hoses no more than 10 feet from the operator.

- Avoid pointing a gun or nozzle at anyone or any part of your body. Hold the gun or nozzle by the grip and remove your fingers from the trigger when handling or carrying the equipment.

- Release all pressure before disconnecting any part of the equipment.

1-7. Regulations Affecting Protective Coatings and Their Use. Before we continue with fire and health hazards, you need to have an understanding of some of the regulations that have been passed and how they are affecting the products you may use. Most of the revisions made in Painting I are due to the changes brought on by regulations passed recently. Perhaps you have already encountered some of them. The following is a brief summary of the key regulations and how they have and will affect you and your work area.

a. Lead. Based on health hazards revealed in studies and past history, the US government enacted the Lead-Based Paint Prevention Act (LBPPA) in 1971. At that time, a protective-coating standard was set at 0.05 percent (500 parts per million by dry weight). Since 1977, the Consumer Product Safety Commission (CPSC) has limited the lead in most coatings to 0.06 percent (600 parts per million by dry weight). However, paint for bridges, marine, and industrial use may contain greater amounts of lead. Lead abatement and/or removal work on projects that have been identified as being lead-contaminated must be performed only by individuals who have received training and are certified. Currently, this work is civilian-contracted by the Department of Public Works (DPW). If you suspect the presence of lead in your work area, report it through the chain of command to DPW.

b. Volatile Organic Compounds (VOCs). In the 1970s, Congress passed the Clean Air Act and established the Environmental Protection Agency (EPA). The quality of the ozone layer topped the EPA's list. The Clean Air Act and the Clean Air Act amendments of 1990 are affecting the coatings industry by requiring the EPA to restrict emissions of VOCs into the atmosphere. Compliant coatings are being formulated by industries to contain higher amounts of solids and thus less solvent and to increase the use of water as the source of solvents.

c. Oil-Based Coatings. Oil-based coatings are highly flammable and are listed as class C (for exterior use only). Due to the flammability of oil-based coatings, the NFPA has established a standard for its use. The standard restricts the use of oil-based coatings to no more than 10 percent of the interior surface area. Although oil-based coatings have not been restricted from exterior use, the NFPA highly recommends the use of water-based latex enamel. You can expect further restrictions on the use of oil-based coatings. Your local regulations may have already started reducing their use. Be prepared for more changes as protective-coating products are reviewed. Your best approach is to check with your DPW, state, and local regulations. You are required to meet the strictest regulations, regardless of the level they originate from.

d. Material Safety Data Sheet (MSDS). The MSDS is prepared and provided with each shipment of chemicals received at the site. The Occupational Safety and Health

Administration (OSHA) requires manufacturers to provide this informational sheet for coating materials, thinners, or other chemicals that you use and store at the job site. The MSDS must also be posted for easy viewing by users and OSHA inspectors. Your painters need to be instructed on how to read and interpret the information. (See Appendix E for sample MSDSs.) The MSDS may be used for several purposes, such as-

- Identifying chemical ingredients in coating materials.
- Assessing technical data like flash points, lower explosion level (LEL), upper explosion level (UEL), OSHA's permissible exposure limit (PEL), odor, and health hazards.
- Selecting proper personal-protective practices and establishing proper storage practices.
- Determining measures to take when cleaning up spills or leaks.

1-8. Fire Hazards. Most paint products are highly flammable and extremely dangerous when they or their vapors are exposed to open flames, sparks, or excessive temperatures. Flammable liquids and vapors, especially the latter, are by far the chief causes of fire and explosion. Forms of flammable liquids and vapors are solvents, oil paints, and some components in other paints.

a. Solvents. Most paint products are flammable because of the solvents they contain. Solvents are highly volatile and some will flash in the presence of a flame or at temperatures below the safe temperature recommended on the paint can label. Because of this, they may be safe in cold weather yet be potentially dangerous in midsummer. It is safer to use paint materials that will flash at temperatures significantly higher than the painting temperature since environmental changes can quickly change a safe condition to a dangerous one. For example-

(1) Safety and blending of flash points. Mineral spirits with a flash point of 105°F are considerably safer to use than a varnish that is a naphtha and benzene compound which has a flash point of 50°F or less. Furthermore, paint, varnish, or lacquer that contains a mixture of solvents will flash at a temperature close to that of the most volatile solvent. This is because the most volatile solvent vaporizes more quickly than the others.

NOTE: A low-flashing paint material cannot be made safe by blending it with another paint having a higher flash point.

(2) Vapor concentration and static electricity in enclosed spaces. Low-flashing solvents volatilize or vaporize readily, and they are most likely to bring about high concentrations of vapor in enclosed spaces. This is especially true when you are spraying, since spray paints usually contain low-flashing solvents to accelerate drying. A spray gun, which applies from a pint to a quart of paint per minute, will cause a much greater concentration of vapor than a dozen brush painters. Every gallon of solvent in the paint is capable of creating large amounts of potentially dangerous gas. This condition is even more dangerous in confined spaces. If a critical ratio of solvent vapor to air is reached in this space, it is possible to cause an explosion in the presence of a flame or spark. This is

why you must ground spray equipment to prevent ignition by a spark from static electricity.

(3) Vapor concentration and flash points in enclosed spaces. Solvent vapors, which are heavier than air, will move along the ground for dozens of yards from the area of application. For this reason, you must extinguish all flames anywhere near the painting area. The flash points and flammable vapor/air limits of common paint solvents are given in Appendix D.

b. Oil-Based Paints. Many exterior paints for wood and steel are based on raw or refined linseed oil. These represent a very definite fire hazard if you allow paint-soaked waste or wiping rags to remain lying around. As the paint dries, the oxidation of the oil can cause the temperature to rise to the point where the rag or waste material will ignite spontaneously. The situation is especially dangerous if rags are contaminated with pure raw or boiled linseed oil (Figure 1-21).

c. Other Paints. The majority of paints that you apply on site contain high-flashing solvents (over 100°F); therefore, they are relatively low in hazard and require only normal precautions. However, some finishes represent an abnormal fire and explosion hazard. Among these are spray finishes with low- flashing solvents as described above. Others are nitrocellulose lacquers that burn rapidly because of the nitrocellulose present and two-component products that are subject to spontaneous combustion if mixed in large quantities.

Figure 1-21. Keep combustibles stored in tightly covered, metal waste cans

1-9. Precautions and Prevention.

You, as the supervisor, must ensure that certain general safety rules regarding fire and explosion hazards are applied to all situations.

- Ensure that all paint materials have complete label instructions which stipulate the potential fire hazards and precautions to be taken.

- Advise and remind painters continuously of the fire hazards that exist under the particular conditions of each job. This is to ensure that they are aware of the dangers involved and take and maintain the necessary precautions.

- Make fire-fighting equipment (of the proper type) readily available in the paint shop, spray room, and work areas where a potential fire hazard exists.

- Ensure that electrical wiring and equipment installed or used in the paint shop (including storage room and spray room) conforms to the applicable requirements of the National Electrical Code for hazardous areas.

1-10. Specific Safety Measures. It is important that you and your painters perform in a safe manner by observing safety measures and fire-prevention safety rules.

a. Safety Measures. You must ensure that the following safety measures are practiced by your personnel.

- Observe "no-smoking" rules in areas where paint is stored, prepared for use, or applied.
- Provide adequate ventilation in all storage, preparation, and application areas.
- Perform recurrent spray operations on portable items (such as signs) in an approved spray booth equipped with adequate ventilation, a water-washing system for fume removal, and explosion-proof electrical equipment.
- Wet down booth surfaces before cleaning them.
- Use rubber feet on metal ladders and ensure that personnel working in hazardous areas wear rubber-soled shoes.
- Use nonsparking scrapers and brushes to clean metal surfaces where fire hazards are present.
- Avoid storing flammable materials in an area where there is a chance that fumes could be ignited by the pilot flame of a water heater or furnace.
- Wet down paint sweepings, rags, and waste with water and store them in closed, metal containers in an approved manner while waiting for disposal. Never burn disposal items in heaters or furnaces.
- Extinguish all pilot lights on water heaters, furnaces, and other open-flame equipment on all floors of the structure being painted. Ensure that gas valves are also turned off.
- Turn off and tag all switches to prevent them from being turned on inadvertently when painting in confined areas near machinery or electrical equipment.

- Use explosion-proof and electrically grounded equipment such as mixers, pumps, motors, and lights in the paint shop, spray room, or on the job.

- Use pails of sand (never sawdust) near dispensing pumps and spigots to absorb any spillage or overflow.

- Keep fire extinguishers nearby during painting operations. Select extinguishers based on the proper type indicated in Table 1-2.

- Check ventilation and temperature regularly when working in confined areas.

- Consult with electricians before painting in areas where high-voltage lines and equipment are located.

- Keep all work areas clear of obstructions.

- Clean up before, during, and after painting operations. Dispose of sweepings and waste daily.

Table 1-2. Proper fire extinguishers

Type of Fire Extinguishers	Class A Fires Consist of fires in paper, wood, cloth, excelsior, rubbish, and such. Use this extinguisher class where the quenching and cooling effect of	Class B Fires Consist of burning liquids (gasoline, oil, paints, cooking fats, and such). Use this extinguisher class where smothering action is required.	Class C Fires Consist of fires in live electrical equipment (motors, switches, appliances, and such). Use this extinguisher class where a nonconducting extinguishing agent is required.
Carbon Dioxide (CO_2)	Use on small surface fires only	It leaves no residue and does not affect equipment or foodstuffs.	It is a nonconductor leaves no residue, and will not damage equipment.
Dry Chemical	Use on small surface fires only	It absorbs heat, releases smothering gas on the fire, and shields the operator from the heat.	It is a nonconductor of fog or dry chemicals and shields the operator from the heat.
Multipurpose (ABC) Dry Chemical	This multipurpose, dry-chemical fire extinguisher has been tested and approved for class A, B, and C fires. It performs in the same manner as the dry-chemical fire extingusher.		
Water	Water saturates the material and prevents rekindling.	Do not use. Water will spread the fire, not put it out.	Do not use on live electrical equipment because water is a conductor.
Foam (being phased out)	Foam has smothering and wetting action.	Do not use. The smothering blanket does not dissipate and floats on top of most spilled liquids.	Do not use on live electrical equipment because foam is a conductor.

b. Fire Extinguishers, Descriptions, Class Uses, and Directions. With the exception of water, the three most common types of fire extinguishers are-

(1) CO2 extinguishers (Figure 1-22, page 1-31) may be used on Class B and C fires. To operate a C02 extinguisher, pull the seal locking pin and open the operating valve. Direct the C02 toward the base of the fire with a sweeping motion.

(2) Dry chemical extinguishers may be used on Class B and C fires. These units contain a dry powder, usually sodium bicarbonate, and an activating agent of CO_2 or nitrogen gas. Do not use these units on trash fires. To operate the extinguisher, remove the locking pin, open the cartridge discharge valve, and squeeze the nozzle handle.

(3) Foam extinguishers (Figure 1-23, page 1-31) may be used on Class A and B fires. For a fire involving liquids, invert the extinguisher and direct the hose so that the foam is played over the surface of the fire. In a solid-material fire, direct the stream of foam to fall lightly on or flow over the burning surface of the material.

c. Fire-Prevention Safety Rules. Observe the following safety rules in connection with fire prevention:

- Prevent the obstruction of approaches (driveways, doors, and aisles) to fire-fighting apparatus or equipment.
- Avoid using flammable liquids to start fires in a salamander or a rubbish pile.
- Use a low-hazard solvent, preferably nonflammable, instead of gasoline as a cleaning agent.
- Avoid the use of a gasoline furnace or a blowtorch where flammable vapors are present.
- Train all personnel in the use and the proper selection of a fire extinguisher that is appropriate to the different classes of fires.
- Notify the fire department immediately whenever a fire extinguisher has been used so that it can be recharged or replaced.

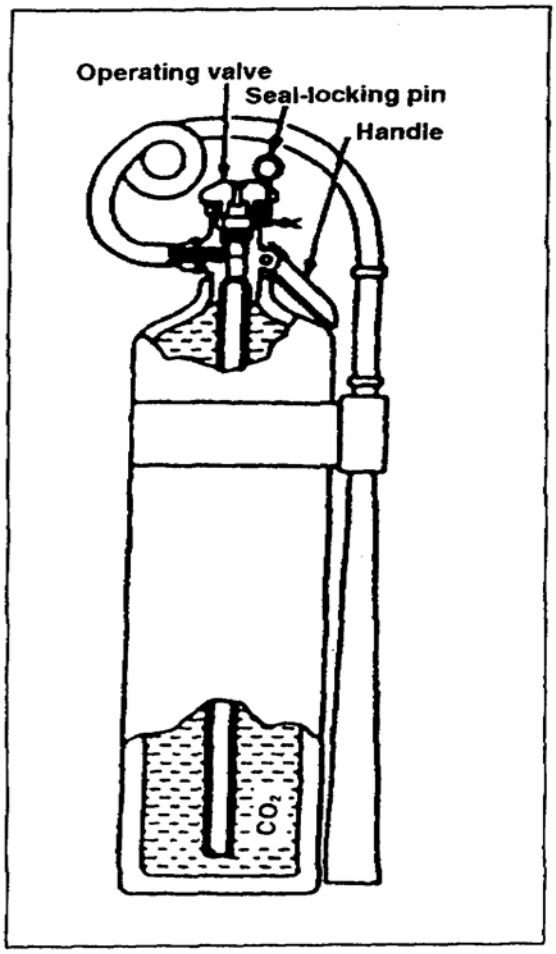

Figure 1-22. CO_2 fire extinguisher

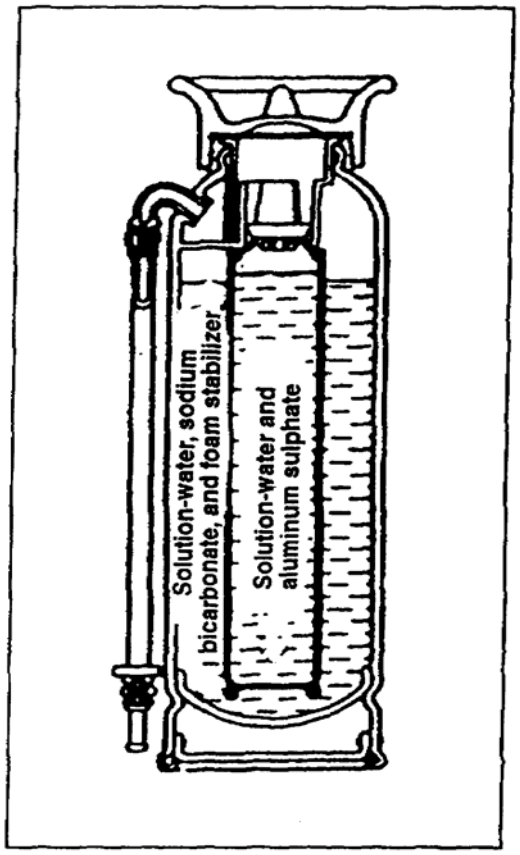

Figure 1-23. Foam fire extinguisher

1-11. Health Hazards. A variety of ingredients used in the manufacture of paint materials are injurious to the human body in varying degrees. While the body can withstand nominal quantities of most of these poisons for relatively short periods of time, continuous exposure or overexposure to them may have harmful effects. Furthermore, continued exposure to some material may cause the body to become sensitized so that subsequent contact, even in small amounts, may cause an aggravated reaction. To this extent, these materials are a very definite threat to the normally healthy individual and a serious danger to persons with chronic illnesses or disorders.

a. Causes of Health Hazards. Hazardous materials are divided into two major groups; they are toxic materials and dermatitic (skin-irritating) materials.

(1) Toxic materials. Toxic materials may be present in the form of vapor, dust, or spray mist and may enter the body either by breathing, swallowing, or absorbing through the skin. Possible symptoms of excessive exposure are irritation of the nasal

membranes, headache, dizziness, loss of appetite, nausea, and fatigue. Typical examples of toxic materials are as follows:

- Pigments. The most common toxic pigments are lead-containing compounds and zinc chromate. Lead may be present in white or tinted paints as white lead; in primers as lead chromate, red lead, or basic lead silica chromate; and in paint dryers. The CPSC banned lead-based paints for residential use in 1978. Almost all paint manufacturers have removed toxic pigments (such as lead) from their products, and many good alternatives are available. Refer to the product specifications for the analysis, and instruct your personnel to take proper precautions if the level of toxic pigment is greater than 1 percent of the total weight of solids in the dry paint film.

- Solvents. The maximum allowable concentrations (threshold-limit value [TLV) for common paint solvents are listed in Appendix D. Among the most toxic solvents are benzol (benzene), methyl (wood) alcohol, and chlorinated solvents (such as carbon tetrachloride). However, these solvents are rarely used in common paint materials.

- Binders. Some binders or vehicles are toxic; for example, epoxies, amines, polyurethanes, and polyesters. Caution your personnel to avoid breathing the fumes or spray or contacting binders with skin. In addition, personnel should always wash their hands and face thoroughly before eating or smoking.

- VOCs. The compounds are defined by the EPA as a group of chemicals that react in the atmosphere with nitrogen oxides (combination compounds from automotive emissions and burning of fuels) in the presence of heat and sunlight to form ozone and air pollutants. Ozone in the lower atmosphere also is known as smog, a pollutant detrimental to plants and humans. The EPA has been directed to regulate VOCs. Control-technique guidelines were issued in the 1970s. Regulations are being developed at the national level. State and local governments have passed regulations; however, permissible VOC emissions vary widely, depending on the generic type of protective coating and the location where it is applied. When you are checking for acceptable coating products, look for the statement "VOCs as applied" rather than the amount of VOCs in the can. New protective-coating products are being added to the VOC regulations list, and new rules are being established. Check the VOC regulations in the area where you intend to apply the protective coatings before selecting a product.

(2) Dermatitic materials. Dermatitic materials affect the skin. The skin becomes irritated, and if left untreated, infection can set in and progress to allergic sensitization and finally to incapacitation and hospitalization. The following are typical examples of dermatitic materials:

- Solvents. All solvents tend to remove natural oils and fats from the skin, leaving it dry, chapped, irritated, and sensitive to infection. Milder solvents, such as mineral spirits, are not as irritating to the skin as stronger solvents, such as turpentine, xylol (xylene), methyl ethyl ketone (MEK), or methylene chloride. (Methylene chloride is the most common solvent used in nonflammable paint removers.)

- Resins and resin hardeners. Epoxy resins, amine hardeners, and some urethane and polyester resins irritate the skin and should be handled with special care.

- Corrosive agents. Corrosive agents in paint removers and paintbrush cleaners (such as phenol acid [carbolic acid] and alkaline cleaners) and acid components of wash primer are also dangerous if handled carelessly.

b. Precautions and Prevention. You can easily avoid health hazards by using a common-sense approach of avoiding unnecessary contact with hazardous materials and by strict adherence to established safety measures. For additional information, refer to AFJI 48-107.

c. Specific Safety Measures. The following rules should be strictly observed by all personnel:

(1) Identify toxic or dermatitic materials and keep them tightly sealed when not in use.

(2) Designate a competent person to check the operation of spray booths. Check at regular intervals to ensure that the equipment is in a safe and proper operating condition.

(3) Ensure that ventilation is adequate in all painting areas. Provide artificial ventilation where natural ventilation is inadequate. Use supplied air respirators, if necessary.

(4) Spray all portable items within exhaust-ventilated booths especially designed for that purpose.

(5) Wear goggles and the proper type of respirator when spraying, blast-cleaning, or performing any operation where any abnormal amount of vapor, mist, or dust is formed.

(6) Use protective creams (or preferably gloves) and wear appropriate clothing when handling dermatitic materials. Change and clean work clothing regularly.

(7) Avoid touching any part of your body, especially your face, when handling dermatitic materials. Also wash your hands and face thoroughly before eating and at the end of the day.

1-12. Emergencies and Health Services.

a. First-Aid Emergencies. Provide well-stocked, first-aid kits containing fresh materials and make them easily available and accessible during any painting operation. Ensure that all personnel are able to give emergency first aid. However, report any illness to the medical and industrial safety departments, regardless of whether or not it appears to be serious. Some toxic materials do not take full effect for days.

b. Health Services. Health services include working with the installation medical department, performing medical exams, and managing medical records.

(1) Medical department. You must consult with the installation medical department regarding any questions or problems relating to the personal health and hygiene of the men or women assigned to you. Decisions in this area are made by the installation medical officer and must be strictly followed. Recommendations made by the medical department are to be presented to your painting crew and enforced by you.

(2) Medical examinations and records. All painting personnel are initially required to have thorough medical examinations with the results entered into their permanent-record files. Subsequent examinations may be required periodically before personnel assigned to the painting crew can be exposed to any job or paint material considered to be at all hazardous. You should immediately request a medical examination of any person suspected of having an illness or affliction which may have been the result of a past painting operation or which may be aggravated at the next assignment.

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LESSON 1

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answer with the key that follows. If you answer any item incorrectly, study again that part which contains the portion involved.

1. Of the following types of paint, which is NOT flammable?

   A. Oil-based paint
   B. Red-lead primer paint
   C. Rubber-based paint
   D. Water-based paint

2. Painters who are sensitive to skin-irritating materials must take special precautions. Of the following, which is the only safe material that they can use?

   A. Water-based paint
   B. Varnish
   C. Oil-based paint
   D. Textured paint

3. Which of the following items would you use to protect yourself against paint fumes and solvent vapors?

   A. Safety goggles
   B. Dispersoid-filter respirator
   C. Safety helmet
   D. Chemical-cartridge respirator

4. You wear a safety helmet for protection against which of the following?

   A. Blast cleaner
   B. Solvent vapor
   C. Falling object
   D. Acid cleaner

5. Painters should not wear clothing with tears, rips, or loose pockets because they are _____.

   A. Distracting
   B. The cause of accidents
   C. Unsightly
   D. Not useful

6. Which of the following is the most important when working in a hazardous area?

A. The use of a drop cloth
B. The use of disciplinary action
C. The use of a buddy system
D. The use of duplicate equipment

7. The most common and most serious accidents that occur during painting operations are caused by _____.

A. The inhalation of fumes
B. The improper storage of equipment
C. The presence of fire
D. The loss of footing

8. In feet, how tall may a stepladder be when painting?

A. 10
B. 12
C. 14
D. 16

9. What is the minimum percentage of overlap required for each section in an extension ladder?

A. 10
B. 15
C. 20
D. 25

10. You are placing a ladder against the wall of a structure. What is the least distance from the wall that you would place the feet of the ladder?

A. 2 feet
B. 1 yard
C. One-fourth the working length of the ladder
D. One-half the working length of the ladder

11. Full-length guardrails must be provided for a scaffold when it is at what height above the ground?

A. Any height
B. 25 feet
C. 50 Set
D. Twice the length of the scaffold

12. Most paint products are flammable. What are the chief causes of fire and explosions?

A. Liquids and vapors
B. High-flashing solvents
C. Rubber-based paints
D. Damar varnishes and lacquers

13. In inches, what is the diameter of the smallest casters you may use on a rolling tower?

A. 3
B. 4
C. 5
D. 6

14. It is standard practice to use wire rope of at least 3/4-inch diameter for platform slings. In inches, what is the least diameter of Manila rope you would select for boatswain's chairs and lifelines?

A. 1/2
B. 5/8
C. 3/4
D. 1

15. Which of the following items would you place under dispensing pumps and spigots to absorb possible spillage or overflow?

A. An oil rag
B. A pail of sand
C. A box of sawdust
D. A pail of water

16. What precaution should you take with paint rags and waste?

A. Burn them
B. Soak them in oil and leave in place
C. Wet them down with water and store in closed, metal container
D. Wash them and dry thoroughly

17. Which of the following solvents is least irritating to the skin?

A. Mineral spirits
B. Turpentine
C. MEK
D. Xylol

LESSON 1

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer	
1.	D.	Most paint materials are hazardous to some degree. All paints, except water-based, are flammable; many are toxic, and others can irritate the skin. (page 1-2, para 1-la)
2.	A.	All of your personnel should be in good health. Painters who are sensitive to or skin-irritating materials should only work with nonsensitive paint materials such as water-based paints. (page 1-3, para 1-2a)
3.	D.	Chemical-cartridge respirators. The respirators are used for protection against fumes and solvent vapors. The respirators contain activated-carbon cartridges that absorb the fumes or vapors. (page 1-4, para 1-2c[1][b])
4.	A.	Abrasive-blasting helmets are used when you are blast-cleaning surfaces that will be painted. (page 1-5, para 1-2c[2])
5.	B.	Wear clothing that is safe for work conditions. Clothing with cuffs, tears, rips, or loose pockets; loose ties; and jewelry are potential causes of accidents. (page 1-6, para 1-2c[4])
6.	C.	Personnel should never work alone in hazardous areas. Assign at least two men to such jobs, and ensure that each is visible to the other at all times during the painting operation. (page 1-6, para 1-2c[5])
7.	D.	The most common and most serious accidents, by far, are falls either from a height or on the ground because of a loss of footing. (page 1-8, para 1-4)
8.	A.	Use stepladders that are 10 feat or less in height. (page 1-9, para 1-6a[2])
9.	B.	Use extension ladders that have a minimum overlap of 15 percent for each section. (page 1-9, para 1-6a[2])
10.	C.	Place ladders so that the horizontal distance from the support structure to the ladder foot is at least one-fourth of the working length as shown in Figure 1-7. (page 1-10, para 1-6a[2])
11.	A.	Provide guardrails, regardless of working height, on the full length of the scaffold and also on the ends. (page 1-11, para 1-6b[1])

12. A. Flammable liquids and vapors, especially the latter, are by far the chief causes of fire and explosion. (page 1-25, para 1-8)

13. D. Provide unit lock arms on all towers. Do not use casters less than 6 inches in diameter. (page 1-20, para 1-6c)

14. C. For boatswain's chairs and lifelines, use Manila rope that is at least 5/8 inch in diameter. (page 1-22, para 1-6e)

15. B. Use pails of sand (never sawdust) near dispensing pumps and spigots to absorb any spillage or overflow. (page 1-28, para 1-10a)

16. C. Wet down paint sweepings, rags, and waste with water and store them in dosed, metal containers in an approved manner while waiting for disposal. (page 1-27, para 1-10a)

17. A. Milder solvents, such as mineral spirits, are not as irritating to the skin as stronger solvents, such as turpentine, xylol (xylene), MEK, or methylene chloride. (pages 1-32, para 1-11a[2])

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LESSON 2

PROTECTIVE-COATING MATERIALS

OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn about the selection and the use of paints and the methods required for safely handling and storing paint materials.

TERMINAL LEARNING OBJECTIVES:

ACTION: You will learn to describe correct procedures for choosing protective-coating materials and the proper methods for storing and handling such materials.

CONDITION: You will be given the material contained in this lesson.

STANDARD: You must complete the lesson and the practice exercise.

REFERENCES: The material contained in this lesson was derived from the TM 5-800 series, TM 5-618, EM 1110-2-3400, AFJI 48-107, and NFPA 101.

INTRODUCTION

As a painter, one of your concerns is being able to select the correct paint or covering to apply to a surface. In addition, you should be able to handle and store these materials effectively without loss or damage to them.

Why do we paint? What is the best protective coating to use? How can I do a professional job of painting? How can I mix the correct colors? How should I store protective coatings? These are questions that you, as a protective-coating specialist, will probably ask yourself. By studying this lesson, you should be able to answer them.

PART A: PURPOSE, COMPOSITION, AND TYPES OF PROTECTIVE-COATING MATERIALS

2-1. Painting Terms. The following are some of the common terms found in protective-coating materials that you will encounter in this lesson as well as throughout the ACCP. They will assist you with your understanding of protective coatings.

- Alkyd resins. Alkyd resins are a blend of alkyl and acid used for protective-coating materials.

- Binder. A binder is something (a resin, drying oil; latex emulsion; film former; vehicle) that produces or promotes cohesion of loosely assembled substances.

- Drier. A drier is a chemical that promotes oxidation or drying of paint.

- Drying oil. A drying oil (linseed oil) is an oil that changes readily to a hard, tough elastic substance when the oil is exposed as a thin film to air.

- Nonvolatile. A nonvolatile is the solid, nonevaporating portion of a paint that is left after the solvent evaporates.

- Pigment. A pigment is the powdered or paste substance that is mixed with a liquid in which it is relatively insoluble and used especially to impart color to coating materials (paints), inks, plastics, or rubber. It is the solid coloring agent that is dissolved in the vehicle.

- Polymerization. Polymerization is the chemical reaction in which small molecules combine to form large molecules.

- Resin. Resin is a material, natural or synthetic, that is contained in varnishes, lacquers, and paints. Solids are the film-former.

- Solids. Solids are the part of a solution or suspension that has the qualities of solids when they are freed from the solvent or suspending medium. Solids are the nonvolatile portion of paints.

- Solvent. A solvent is a liquid in which another substance is dissolved.

- Vehicle. A vehicle is any of various media acting as a solvent, a carrier, or a binder for active ingredients or pigments. Anything dissolved in the media portion of paint is a part of the vehicle.

- Volatile. A volatile fluid is a substance that evaporates rapidly at relatively low temperatures.

2-2. Protective-Coating Composition. To select the best protective coating for a given surface, it is important that you understand the composition of coatings. All coatings--whether used for corrosion protection, to provide good aesthetics or a pleasing appearance, or for any other purpose-will contain a film-forming material. This material may be organic or inorganic and after it has been applied, it may form a hard, impervious film, a soft porous film, or combinations in between. The film-forming material may be clear (unpigmented) or filled with a variety of different pigments, depending on its function. When the film-forming material (resin) contains pigments, it is called a binder. The binder will hold the pigment particles together and hold them to the surface they have coated. When the binder (resin plus pigment) is dissolved in a solvent to make a liquid, the

combination (solvent, binder, and pigment) is considered to be a vehicle. The term vehicle comes from the ability to transport and apply the liquid to the surface being coated. Once on the surface, the solvent evaporates and the vehicle becomes a pigment-binder system. Paint application properties (such as spreadability) are usually characterized by the vehicle in its liquid condition. The viscosity, rate of solvent evaporation, and consistency of the wet coating are most important during application. After application, the pigments determine the corrosion-inhibitive properties and, generally, the color and some flow-control properties of the applied coating. The binder determines the weatherability of the coating, its environmental resistance, and its ability to function in a given environment. The required surface preparation, and often the application equipment and techniques, are determined by the binder.

2-3. Purpose and Function of Protective-Coating Materials. The military uses paint to camouflage weapons and installations and, recently, for identification purposes. The use of and demand for protective coatings have grown until, today, over 5 billion dollars each year is spent on them. The military, along with other government agencies and commercial establishments, uses a considerable quantity of these coatings for protection, sanitation, cleanliness, illumination, visibility, safety, efficiency, appearance, camouflage, and fire retardance.

a. Protection. Protection of the surface is the most important purpose for paint. If properly chosen and applied, your painting efforts will protect wood buildings from moisture and sunlight, metal structures from corrosion, and concrete and masonry surfaces from the weather. Paint, when regularly programmed, offers long-range protection that extends the useful life of a structure.

b. Sanitation and Cleanliness. The use of paint and proper painting operations will promote sanitation and cleanliness. Paint provides smooth, nonabsorptive surfaces that are easily washed and kept fee of dirt. Such surfaces tend to keep foodstuffs from adhering. Adhering foodstuff harbors germs and causes disease. The coating of rough or porous areas seals out dust and grease that would otherwise be difficult to remove. Paint coatings will reveal buildup of foreign substances, indicating that better housekeeping practices are in order. Paint coating, therefore, is an essential part of general maintenance programs that is performed for hospitals, mess halls, offices, warehouses, and living quarters.

c. Illumination and Visibility. When white or light-tinted paints are applied to ceilings and walls, they reflect both natural and artificial light, help brighten rooms, and increase visibility. On the other hand, darker colors reduce the amount of reflected light. Flat paints diffuse, soften, and evenly distribute illumination; whereas gloss finishes reflect more like mirrors and may create glare. Color contrasts improve visibility of the painted surface, especially when paint is applied in distinctive patterns. For example, white on black, white on orange, or yellow on black can be seen at greater distances than single colors or other combinations of colors.

d. Safety and Efficiency. A recent innovation is to use paint for the identification of pipes carrying different material, such as oil, steam, water, and air, through a hangar or an industrial plant. Paint is also used to indicate hazards or danger areas by using various

colors. This area usage of paint is expanding at a very rapid pace, especially in schools, hospitals, other institutions, and industrial plants.

e. Appearance. The primary use of paint is to provide maintenance and improve safety and efficiency. Decorative painting is sometimes considered to be secondary in importance and is therefore kept at a minimum. However, the functional use of color creates comfortable living and working conditions and more pleasant surroundings that result in improved morale and increased efficiency.

f. Camouflage. The military forces use paint to camouflage weapons and installations against enemy detection. As a result of expert application of colors that blend with the surrounding terrain, the enemy has difficulty detecting the locations of weapons, supplies, buildings, or even ships from the air.

g. Fire Retardance. Application of fire-retardant paint will delay the spread of fire and assist in confining it to its origin. This allows more time during which fire-fighting equipment can arrive to extinguish the blaze before it gets out of control. The use of fire-retardant paint is restricted to appreciable areas of highly combustible surfaces and for selected uses. Use of this paint type is further restricted to interior surfaces except for Arctic areas. You should not consider fire-retardant paint as a substitute for conventional paints because its cost is much higher.

2-4. Principle Ingredients of Protective-Coating Materials. The principal paint ingredients are the pigment and the vehicle. The pigment is the part of the paint that constitutes the solids, and the vehicle is the fluid. The many types of materials used in the formulation of paint are far too numerous to describe in this lesson; however, in order to acquaint you with the most common paint pigments and vehicles, they are discussed as a class, and in some instances, the more important materials in a class are described.

2-5. Pigments. Pigments are fine, solid particles used in the preparation of paint, which are insoluble in the paint vehicle. Pigments are available in two forms: paste and powder. Powder forms a stiff consistency when combined with oil, lacquer, or an other vehicle. There are five main types of pigments to use: white, color, metallic, black and extender.

a. White Pigments. White pigments are of great importance to you and the paint industry because white is a widely used color and serves as the base for popular pastel or tinted colors. The most common white pigments used are titanium dioxide and antimony oxide. Due to regulations, lead and zinc-oxide pigments are no longer in use or are restricted to 0.06 percent or less of the paint's content.

(1) Titanium dioxide. This white pigment has been available since 1932. It has a definite advantage where maximum hiding is required. Titanium dioxide has overshadowed all other white pigments because of its chalking ability. This means the surface becomes chalky, and you can rub or wash it off. This is an obvious advantage when white or light-colored house paint is used because rain will wash away the chalk, and along with it goes the dirt and the grime, leaving a clean, bright surface. Its disadvantage is with dark colors because it gives a fading appearance to the color.

(2) Antimony oxide. This pigment is used chiefly in the manufacture of fire-retardant paint, where it is used in combination with chlorinated materials and calcium carbonate. The Navy uses paints with this type of pigment on interior surfaces of its ships.

(3) Zinc oxide. This is one of the finest of all white pigments and actually one of the whitest. It is opaque to ultraviolet light and, when incorporated in a paint, protects the film from the destructive action of the ultraviolet rays in sunshine. While zinc oxide contributes to the hiding power of paint, some of its other properties are more important. It is not discolored by sulfur gases in the atmosphere, and it is nonpoisonous. Zinc oxide is used as a preventive for mildewing or yellowing and also adds hardness to a paint film. It is a valuable pigment for controlling checking, chalking, and dirt retention of exterior paint films. It is also used in metal-protective paint for rust inhibition and in other paints for greater resistance to scrubbing. There is a current trend to use latex primers in place of zinc-oxide paint for rust-inhibition work.

b. Color Pigments. Color pigments can be obtained from deposits in the earth's crust or through chemical processes.

(1) Earth colors. The most widely known earth colors in the painting industry are yellow ocher, raw and burnt sienna, and raw and burnt umber:

- Yellow ocher. This color contains hydrated iron oxide as a coloring matter. Various ochers contain from 10 to 60 percent hydrated iron oxide, the remainder being siliceous matter or clay. In color, yellow ochers vary from pale to very dark yellow, almost olive. When of good quality, they are excellent pigments, permanent in color, and combine well with all paint vehicles as well as other pigments. When used with white pigments, they will produce fine-cream or buff tints. They are primarily used as tinting colors.

- Raw sienna. This color resembles yellow ocher in general composition, since it is colored by hydrated iron oxide. It is brownish-yellow in color. When used with white, it produces cream tints which have greater color strengths than ochers. Raw siennas are valuable for use as staining and graining colors. However, they are undesirable for base colors.

- Burnt sienna. This color is obtained by roasting raw sienna, thereby producing a strong, reddish-brown pigment. Burnt sienna is used to a lesser degree than raw sienna. However, it is a very valuable pigment when used for shading and glazing.

- Raw umber. This color is similar in composition to sienna. It has a greenish-brown color, is permanent, possesses medium opacity, and mixes well with paint vehicles. Raw umber gives drab tints to white and gives a great variety of other shades when mixed with color pigments, and it is used extensively for these purposes.

- Burnt umber. This color is calcined (roasted) raw umber. It possesses a rich, brown color that is darker than raw umber and free of redness. Burnt umber is used in practically all types of paints and stains.

(2) Chemical colors. Chemical colors are very important today and are used more than earth colors because they can be produced cheaper by chemical reaction than from basic raw materials. These colors consist of blue, green, maroon, orange, red, yellow, brown, and violet pigments.

c. Metallic Pigments. Metallic pigments are used to form a metallic film (barrier) in paint. The most common are aluminum, copper brown, and zinc:

(1) Aluminum pigments. These pigments are largely pure metallic aluminum and contain appreciable amounts of a polishing lubricant and a mixture of stearic and other fatty acids. They are purchased in either paste or powder form. An average formula mix for the production of aluminum paint is 2 pounds of aluminum powder or paste to 1 gallon of mixing varnish.

(2) Copper pigments. Copper brown powders are usually alloys of copper with small amounts of zinc and iron. Approximately 1 to 2 pounds of metal per gallon will give good hiding qualities. Copper brown in combination with small amounts of a toxic substance, such as a mercury or arsenic compound, is used for making antifouling ship-bottom paint. Various shades, from a light brass to a dark, antique copper, are used in nitrocellulose lacquer to make the popular brass and bronze finishes.

(3) Zinc pigments. Zinc dust is a metallic-gray powder with about 3 percent zinc oxide on the surface. It has gained importance as a pigment for making metal-protective coatings.

d. Black Pigments. One of the most important black pigments known to the paint industry is lampblack. It is most commonly used for shading paints, since it has exceptionally great shading strength and is extremely permanent.

e. Extender Pigments. Extender pigments are certain white or colorless natural substances that are ground into a fine powder and added to paint. They are used to-

- Provide a solid base for color pigments.
- Make the paint film porous so that a normal amount of moisture may pass through it without pushing off the paint film.
- Reduce the excessive spreading rate of paint, thereby increasing the thickness of a paint film.

Some of the more important extender pigments are barytes (barium sulfate), china clay (aluminum silicate), mica, silica (glass sand), talc (magnesium silicate), and whiting (calcium carbonate).

2-6. Vehicles. In a layman's language, the vehicle is defined as the liquid portion of a paint, enamel, lacquer, or similar substance which holds the pigment in the solution. The vehicle may be any of such liquids as volatiles (thinners or solvents) and such solids as nonvolitiles (drying oils, driers, resins, and varnishes). It is perhaps the most important part of the coating, as it furnishes the desired qualities of adhesion, toughness, flexibility,

and resistance to various environments. It gives the paint its strength and life. The vehicle is usually divided into two parts; they are volatiles and nonvolatiles.

a. Volatiles. Volatiles are the nonsolid portions of vehicles that evaporate. They consist of thinners and solvents. Volatiles, more commonly called thinners, are organic liquids that are used to reduce the viscosity (thickness) of a vehicle or paint to a suitable brushing or spraying consistency. Volatiles are also used to control many other properties of paint, such as the ability to penetrate and/or wet the surface being coated, the leveling, the lap time (period between paint coats), the dispersion of pigments, and the ease of brushing or spraying. Some of the more common volatiles are turpentine, mineral spirits, naphtha, xylene, acetone, and various alcohols, ethers, ketones, and esters. Water, of course, is used as a thinner for water-based paints. When selecting volatiles to thin paint for use in the field, you should follow the directions of the paint manufacturer or the specifications, since some paint vehicles will not mix with certain volatiles.

b. Nonvolatiles. Nonvolatiles are the solid, nonevaporating portions of a paint that are left after the solvent evaporates. They are the solid portions of the vehicle that form the actual film on the surface. They consists of film-forming materials, such as drying oils, driers, resins, and varnishes.

(1) Drying Oils. Drying oils are nonvolatile vehicles. A nonvolatile vehicle is defined as the liquid portion of a paint aside from its volatile thinner and water (or other solvent). Not all oils are drying oils. An oil is classified as a drying oil if it will set or harden under normal exposure conditions when applied as a thin film. Some of the most commonly used drying oils are linseed, soybean, tung, oiticica, perilla, fish, and dehydrated castor.

(a) Linseed oil. Linseed oil, the most important of drying oils and the principal nonvolatile paint vehicle, is obtained from flaxseed. It is used as the basic vehicle in paint because it has a natural ability to dry in the open air, forming an elastic, durable, solid film which resists the attack of weather and wear. The addition of a drier will hasten its normally slow hardening rate.

(b) Soybean oil. Soybean oil, a slower drying oil than linseed oil, is generally used with faster drying oils. The main use for it is in varnish vehicles for interior paints and enamels. Paints made with soybean oil resist yellowing. It is used in some of the best interior, white enamels.

(c) Tung oil. This oil is one of the chief oils used in the manufacture of fast-drying, waterproof, oil varnish. Since raw tung oil dries rapidly but not to a smooth film, it is not used in exterior house paint; whereas linseed oil is almost universally used. Its chief usage is in the manufacture of varnish.

(d) Oiticica oil. This oil is extracted from the seeds of certain trees growing in northern Brazil. It is similar to tung oil and is used in the manufacture of paint and varnish.

(e) Perilla oil. This oil is extracted from the seeds of the perilla plant grown in Manchuria. It is extensively used in the manufacture of varnish because of its superior drying and film-forming qualities.

(f) Fish oil. This oil is mostly extracted from the menhaden and the pilchard fish. It is satisfactorily used for covering hot surfaces, such as smoke stacks, where hard-drying paints are not suitable. It is not recommended for interior use.

(g) Castor oil. This oil is produced from the castor-oil plant. Its use has increased since being accepted as a satisfactory replacement for tung oil.

(2) Driers.

(a) Driers are catalytic agents. They hasten film hardening when added to a drying oil or a paint or varnish that contains oil. The most common driers used in paint are oil-soluble naphthenates of cobalt, zinc, manganese, or lead. Lead driers promote hard drying throughout the thickness of the film and influence the polymerization rate of the vehicle more than they do the oxidation rate. Lead driers are not as strongly catalytic as others in promoting the drying of paint films. Cobalt driers assist oxidation strongly and, if used alone, may cause wrinkling because of rapid drying of the outer layer of the film.

(b) Driers are classified as through driers and surface driers. Through driers are compounds of lead, cadmium, zinc, or zirconium. Surface driers are compounds of cobalt and manganese. Use surface driers in conjunction with through driers to prevent wrinkling, uneven drying, and such. Table 2-1, summarizes individual drier characteristics and their effect on the film if the drier is used alone.

Table 2-1. Characteristics of driers

Classification	Compound	Characteristics	Effect If Used Alone
Through drier	Lead, cadmium, zinc, and zirconium	Hard drying throughout	Tough film
Surface drier	Manganese	Intermediate drying	Brittle film
	Cobalt	Rapid drying of outer layer	Wrinkling of film

(c) When using a given paint or vehicle you may make use of one or both of the drier classifications, depending on the nature of the paint product. If too much drier is used or is improperly combined, the drier mixture may adversely affect the durability of the film or may not allow the paint film to harden. It is safer to purchase finished paint products with driers added whenever practicable, since the addition of driers in the field is readily susceptible to error.

(3) Resins. Natural and synthetic resins available to the paint industry are so numerous and varied in properties that they will only be mentioned. This same complexity

and multiplicity make a definition almost impossible. Resins, together with drying oils, comprise the bulk of film-forming materials, or binders, in the surface-coating field. Natural resins, such as resin and shellac, are extracts from trees and insects. Synthetic resins, such as alkyds, alkyd modifiers (vinyls, phenolics, silicones, epoxies), acrylics, and polyurethanes, are manufactured from basic organic material, such as petroleum, alcohol, coal tar, and vegetable oils.

(a) Alkyds. Alkyds are the backbone of modern paint in a great many combinations. The alkyds are characterized by toughness, flexibility, and durability Use them in exterior and interior coatings for utility and decorative purposes. However, they do not have good chemical resistance.

(b) Alkyd modifiers. Other resins (modifiers) are combined with alkyd resins to improve its properties. Examples of alkyd modifiers are vinyls, phenolics, silicones, and epoxies.

- Vinyls. Vinyls are used where construction materials, metal, and wood must be protected from high humidity or an acid-caustic environment.

- Phenolics. Phenolics appear in varnishes and enamels that require extra hardness and abrasion-resistance.

- Silicones. Silicones appear primarily in heat-resistant coatings. They are not particularly hard-surfaced and may craze. They are usually baked.

- Epoxies. Epoxies have outstanding adhesion and chemical resistance. In combination with other resins, they appear as baking enamels. Air-drying types are frequently used with converting agents just prior to application to set up films of improved characteristics.

(c) Acrylics. Acrylics have outstanding light resistance and weather durability, and they have moderate chemical resistance. Used with nitrocellulose as a hardener, they have better drying properties and increased hardness. Styrene acrylic and latex emulsions are some examples of acrylics.

(d) Polyurethanes. Polyurethane coatings are characterized by a very high gloss, superior toughness and weather durability, and good chemical resistance. They are also converted or catalyzed in coating applications.

c. Varnishes. Varnishes contain oil, resins, thinners, and driers. They are produced by combining oils and resins in definite proportions, then adding thinners and driers to the mixture. The various types of resins, oils, and other available components make it possible to produce varnishes adaptable to many uses. You may use varnishes as clear coatings or as vehicles for pigmented paints.

2-7. Types of Protective-Coating Materials. You must determine the best type of protective coatings for your use. There are many factors for you to consider, such as the condition of the surface, the method of application, curing conditions, the service expected

by the user, the cost, and the length of time the appearance must remain satisfactory. The materials mentioned in the previous sections on pigments (paragraph 2-5) and vehicles (paragraph 2-6) are used to make many different types of organic finishes for decorative and protective purposes; however, some of the most common types are oil-based paint, enamel, lacquer, water-based paint, varnish, shellac, and stain:

a. Oil-Based Paint. Oil-based paint consists principally of a drying oil (usually linseed) mixed with one or more pigments. Oil-based paint may be modified by the addition of varnish. The exterior surface of houses and metal surfaces in atmospheric exposure will usually be coated with oil-based paints. The vehicle in these paints can be a combination of raw and processed oils, or it may be a single oil, depending on the properties required in the paint. The pigments and their quantities are usually selected on the basis of cost and their ability to impart the desired application properties, such as durability, economy, brushability, and color. Oil-based paints are characterized by easy application, slow drying, and a good ability to wet the surface being coated. They normally chalk in such a manner that permits recoating without costly surface preparation.

b. Enamel. Enamel is a paint which is characterized by the ability to form an especially smooth film. By definition if the pigment product is relatively easy to brush and is used on large areas such as walls or structural steel, it is called a paint. If it is relatively fast drying, levels out to a smooth, hard finish, and is used on relatively small areas or smooth substructures such as woodwork, it is called an enamel. Enamels are commonly thought of as pigmented, varnish-vehicle paints that have good flow and leveling properties and dry rapidly (4 to 16 hours) at normal temperatures. In general, the ability of enamel to wet the surface and coat surface irregularities is not as good as oil-based paints. Enamels generally fail by chipping, cracking, blistering, or similar action as a result of a gradual decrease of elasticity that comes with age. Enamel films are generally harder, tougher, and more resistant to abrasion and moisture penetration than oil-based paints. Enamel may be applied by brushing, spraying, or dipping. When applying enamel by brush, flow the paint on the surface rather than brushing it out as with oil-based paints. Enamels of the baking type are widely used in industrial finishing.

c. Lacquer. Lacquer differs from oil-based paint and enamel because it contains some type of resin as a vehicle. Lacquer is normally applied by spray since most types dry too fast for brushing. Lacquer is usually applied by a series of thin films. You can obtain a hard, brittle coating; a tough, elastic coating; a high or low gloss film; and many other variations by the proper choice of lacquer materials. The durability of lacquer finishes on some makes of automobiles is proof that good protection is given by lacquer. Vinyls and rubber-based solutions (paints) are technically lacquers. They have outstanding durability in many types of exposures.

d. Water-Based Paint. Water-based paint is distinctly different from other paint because the vehicle is an emulsion of binder and water. The emulsion technology is promising for VOC compliance because water is not a restricted solvent. Water-based paints have the advantages of easy application, drying by evaporation of water, easy reduction of viscosity with water, and easy cleaning of tools with soap and water. This type of paint was originally used as an interior coating; however, with product advances in water-based paints and the increased concern over fire prevention, its usage has broadened

to outside surfaces as well. Water-based paints fall into many categories, but casein, latex, and calcimine are the more important ones.

(1) Casein. In casein paint, casein (protein of milk) is used as the binder. Casein paint consists of powdered casein, hydrated lime, inert and hiding powdered pigments, a preservative, and tinting colors. Small amounts of vegetable oils are added to improve its washability. The principal pigment added to casein paint is titanium. Casein paints usually cover a surface wall in one coat, dry rapidly, and adhere to new, unsealed plaster without blistering the paint. Use casein paints for interior decorative work on plaster, wallboards, fiberboards, stucco, cement blocks, and such. Casein paints are also available for exterior masonry, stucco, brick, and concrete.

(2) Latex (emulsions). This term was originally used to describe raw, latex rubber-emulsion paint (rubber in water). Now, the term is used in connection with all resin and rubber-emulsion paints. Water is used to both thin these paints and clean the brushes. Many types have been made, but vinyl and acrylic emulsions are the most popular. Emulsion paints are very good for use on interior and exterior masonry because they breathe, allowing vapor to slowly pass through the film. Emulsion paints are glossless, and you must ground special colors in a suitable vehicle to color them.

(3) Calcimine. Calcimine is a mixture of powdered pigments, such as whiting and china clay, and glue. You compound the paint by mixing the prepared pigments with water. The paint is an inexpensive way to cover wet (damp) wall and drywall interior surfaces. A compound of glue, a tinted wash, and calcimine may be used on wet walls. The best results, however, are obtained by using a varnish sealer and primer before applying the calcimine.

e. Varnish (Resin). Varnish is a transparent or opaque liquid that provides protection and decoration. It dries to a hard, transparent coating. The kinds and types of varnishes used are numerous. Some manufactures' catalogues list from 100 to 200 varieties. Oil varnishes are the most frequently used and include spar varnish, interior varnish, flat varnish, rubbing varnish, and colored varnish. All of the above varnishes are extensively used to finish and refinish interior and exterior wood surfaces, such as floors, furniture, woodwork, metal fixtures, and so on. They produce a durable, elastic, and tough surface that dries to a high-gloss finish and does not mar easily. Exterior varnishes are specially formulated to resist weathering.

f. Shellac. Shellac comes from the secretions of the scale insect. This insect secretes a resinous material on trees which is gathered, washed, and ground, and then melted and formed into a thin sheet. These thin sheets of shellac are then broken into flakes (one of the forms in which shellac is sold on the market). Shellac is now produced with chemicals in modern factories. Shellac is soluble in alcohol and used extensively on furniture as an undercoat and over knots to prevent bleeding.

g. Stain. Stain is used to change the color of various types of wood and to bring out the beauty of the grain. They are usually applied before the varnish or other finish; however, some oil stains are used as a preservative for shingles and other rough, exterior, wood surfaces. The most commonly used stains are water, spirit, oil, and varnish.

(1) Water stain. Water stain is cheap, penetrates the wood deeply, and is transparent. It produces an even penetration and gives the most even and clearest tone of all stains. A disadvantage in its use is that the water raises the grain of the wood that is being finished, requiring extra sanding. Use water stains for inside woodwork and furniture.

(2) Spirit stain. You make spirit stain by mixing aniline colors in alcohol. They dry quickly, and the colors are brilliant, transparent, and beautiful. When you use a spirit stain, the surface may be stained, filled, and shellacked or varnished the same day. For this reason, spirit stains are useful for repair and touch-up work on floors, woodwork, and furniture and for all sorts of quick jobs. Spirit stains penetrate old varnish surfaces to a greater depth than other stains, but they are not permanent in sunlight or very strong artificial light.

(3) Oil stain. An oil stain is probably the most convenient for finishing woodwork of various kinds. It is easily obtained, easily applied, and does not raise the grain of the wood. It dries slowly enough to permit brushing and rebrushing without showing lap marks. If the color is too dark after the stain is applied, you may wipe off some of it to produce a lighter color. Use Table 2-2 to determine what oil stains to mix, then mix oil stains in a base of 1/2 gallon boiled linseed oil and 12 gallon of turpentine or mineral spirits. For example, to make mahogany, add 1 pint Vandyke brown and 1 1/2 pints rose to the base.

Table 2-2. Mixing oil stains

Oil-Type Wood Stain Color	Mixture Colors						
	Burnt Sienna	Vandyke Brown	Rose	Raw Sienna	Raw Umber	Burnt Umber	Drop Black
Cherry	1 1/2 pints						
Mahogany		1 pint	1/2 pint				
Light oak				1 pint	1/4 pint		
Dark oak	Touch			1 pint		1/2 pint	
Old maple	1/2 pint			1/2 pint	1/2 pint		
Walnut	1 pint	1 1/2 pints					1/4 pint

(4) Varnish stain. Varnish stain is made by adding a stain to a varnish. When you use a varnish stain, it is possible to stain and varnish in one operation.

PART B: MIXING AND PREPARING PROTECTIVE COATINGS

Now that you have a basic knowledge of the types of protective coatings, you are about to undertake the most important task of the trade--mixing and preparing the protective coatings.

2-8. Mixing, Coloring, and Tinting Paints. Coloring and tinting paint is not difficult when a new mixture of paint is first made; however, when you attempt to match paint already applied on a surface, it is difficult because paint changes shades after drying and aging. Coloring and tinting paint is a matter of trial and error. To be a professional protective-coating specialist, it is necessary that you understand the color combinations, color mixing, tinting, and color harmony. You must also understand how to mix paint by boxing (hand mixing) and by using power equipment, how to thin paint, and the special procedures required for mixing aluminum paint.

a. Color Combinations. Skillful mixing of colors is one of the most important aspects of painting and decorating, especially in interior decorating. The 12 colors found on a color wheel are grouped as primary, secondary, and tertiary.

(1) Primary colors. There are three primary colors (Figure 2-1). They are blue, red, and yellow.

(2) Secondary colors. Secondary colors (Figure 2-2, page 2-14) are made by mixing any two of the primary colors together. For instance, yellow and red form orange; red and blue form purple; and blue and yellow form green.

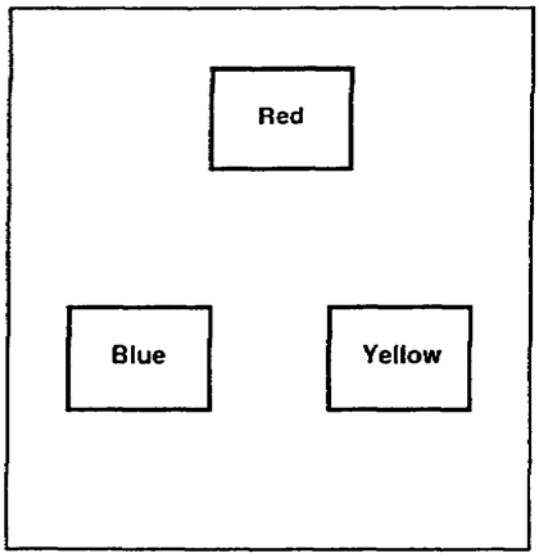

Figure 2-1. Primary colors

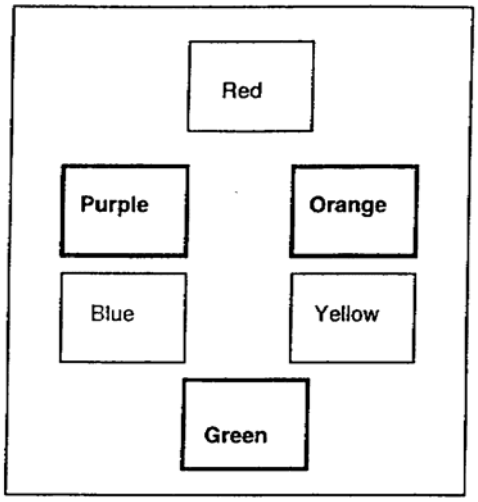

Figure 2-2. Secondary colors

(3) Tertiary colors. The remaining six places on the color wheel are filled by combining adjacent primary colors and secondary colors. These are called tertiary colors (Figure 2-3). This fills the color wheel with 12 colors, all full strength, which are known as hues.

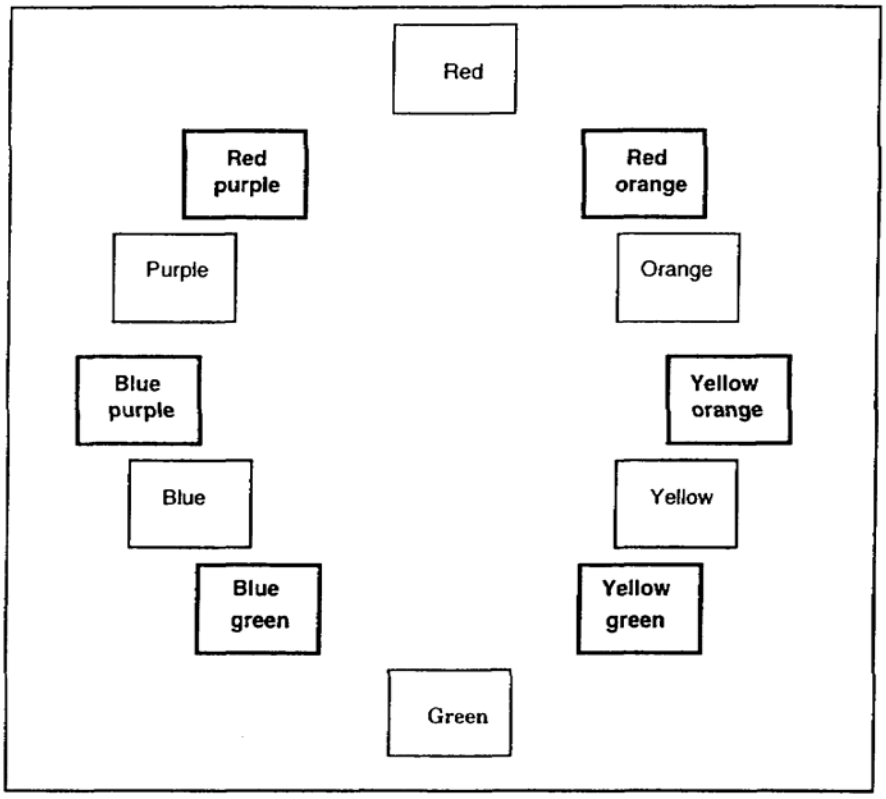

Figure 2-3. Tertiary colors

b. Tints, Tones, and Shades. From the 12 hues, you can attain tints, tones, and shades:

- Tints are lighter than hues and are formed by adding white to the colors on the color wheel.

- Shades are darker than hues and are formed by adding black to the colors on the color wheel.

- Tones are made by adding black and white to the colors on the color wheel.

c. Color Mixing.

(1) Oil-based paint. When you are mixing oil-based paint on the job, colors in oil are easier than powders to mix into the paint vehicle. Colors in oil consist of dry pigments (powders) ground in a vehicle of approximately 80 percent linseed oil and 20 percent volatile solvent. The solvent will make a paste that will satisfactorily flow from containers. The major colors in oil are black, blue, brown, green, orange, red, and yellow:

(a) Black. The blacks are bone black, high-colored carbon black, lampblack, and synthetic black iron oxide. Carbon black and lampblack are the strongest in shading strength. Carbon black and bone black are blacker in color. Lampblack, however, is the one you will most frequently use. Black iron oxide is used as a pigment in black metal-protective paints and is also used for shading purposes. You can thin pastes to brushing consistency by adding three parts linseed oil, one part spar varnish, and one-half part drier to one part of the pigment paste.

(b) Blue. The blues are iron blue (Prussian blue), ultramarine blue, and copper phthalocyanine blue. The permanency of iron blue is affected by alkalies, while ultramarine blue is susceptible to acids. Copper phthalocyanine blue is more durable in the light-blue tints. When exposed to the weather, these pigments have a fair permanency in tints or solid colors.

(c) Brown. The browns include metallic brown, burnt sienna, burnt umber, raw umber, and synthetic brown iron oxide. The browns are among the most durable pigments in paints that are exposed to the weather. Although adaptable as a trim color, metallic brown is more often used as a solid color. It is used to a great extent in paint for barns, metal roofs, and freight cars. The other browns are used more frequently for tinting paints and making stains. Brown iron oxide is also used as a pigment in some paints and enamels.

(d) Green. The greens are chrome green and chromium-oxide green. Use chrome green, composed of chrome yellow and iron blue, to make tints or solid-color paints. Chrome green is sensitive to alkalies. Chromium-oxide green, the more permanent of the greens, is used with white for tinting purposes. It does not have the tinting strength of chrome green but withstands high temperatures and is not effected by alkalies or acids.

(e) Orange. The oranges consist of two shades of chrome orange that are used for tinting and making solid-color paints. The pigments are basic lead chromate that is

processed as light and dark. The dark pigment is used for making international orange paint. Both light and dark pigments are relatively permanent when exposed to the weather. Even though lead chromate is considered hazardous, the pigments in these paints will be difficult to replace because no other pigments have a similar light fastness and brightness.

(f) Red. The reds include Venetian red, bright-red iron oxide, Indian red, toluidine red, and mineral red. All of these pigments may be used for tinting purposes, except toluidine red. Indian red and bright-red iron oxide are very permanent and are used extensively in all types of paints, enamels, and stains. Venetian red and mineral red are often used in barn and roof paints. Toluidine red, which is a bright red, is permanent even when exposed to the weather.

(g) Yellow. The yellows include lemon chrome yellow, medium chrome yellow, yellow ocher, primrose chrome yellow, yellow iron oxide, raw sienna, and zinc yellow. The chrome yellows are satisfactory for tinting exterior paints. Raw sienna is more often used for tints and stains than as a solid-color trim paint. When mixed with white titanium dioxide in different amounts, it makes durable ivory and buff tints. Use yellow oxides particularly in solid-color paints and for tinting floor enamels. Use zinc yellow as a rust-inhibitive pigment in metal primers.

(2) Water-based paint. When you are mixing water-based paint on the job, mix water-soluble color pigments into the paint vehicle.

NOTE: Colors in oil cannot be mixed with water-based paints.

d. Tints or Shades. When you tint or shade paint with paste, mix the paste with a small amount of the paint vehicle to thoroughly break it up then strain it through a cheesecloth. When you mix paint to match a certain color, add the tint or shade in small amounts and test the paint by brushing it on a surface that is similar to the one to be painted. Allow the paint to dry before checking for the proper match. If you have not produced the desired match, add more color or more base paint. If you notice streaks of color when you brush out the paint it is a sign that you have not thoroughly mixed the color into the base paint. If you add too much color to the base paint, you will have to add considerably more base paint to lighten the color. As a result, you will have more paint than you need for the job.

e. Color Harmony. Table 2-3 contains a list of do's and don'ts to consider when you select colors.

Table 2-3. Color selection

Do's	Use light colors in a small room to create an impression of larger size.
	Have continuing color flow through the building, from room to room, using harmonious colors in adjoining areas.
	Paint the ceiling a deeper color than the walls if you want it to appear lower; paint it a lighter shade for the opposite effect.
	Study color swatches in daylight and under artificial light, because colors often change under artificial light.
	Emphasize horizontal lines in a room that is too tall, and emphasize vertical lines in a room with a low ceiling.
Don'ts	Use a bright color in a large area, or the walls will detract from otherwise decorative furnishings and accent pieces.
	Paint the woodwork and the trim of a small room a different color from the background color, or the room will appear cluttered and even smaller.
	Paint unfortunate architectural features, such as radiators, pipes, and similar projections, a color that contrasts with walls, or they will be emphasized.

f. Paint Mixing. You must mix (stir) primers and paints thoroughly. This will ensure that the paint pigment, which usually settles to the bottom of the container, and the paint vehicle are thoroughly mixed together. Mix primers and paint by boxing or using power-operated equipment.

(1) Boxing Use boxing when you are mixing paint by hand. Boxing consists of pouring the paint back and forth from one container to another. To do this, follow the procedures listed in Figure 2-4, page 2-18.

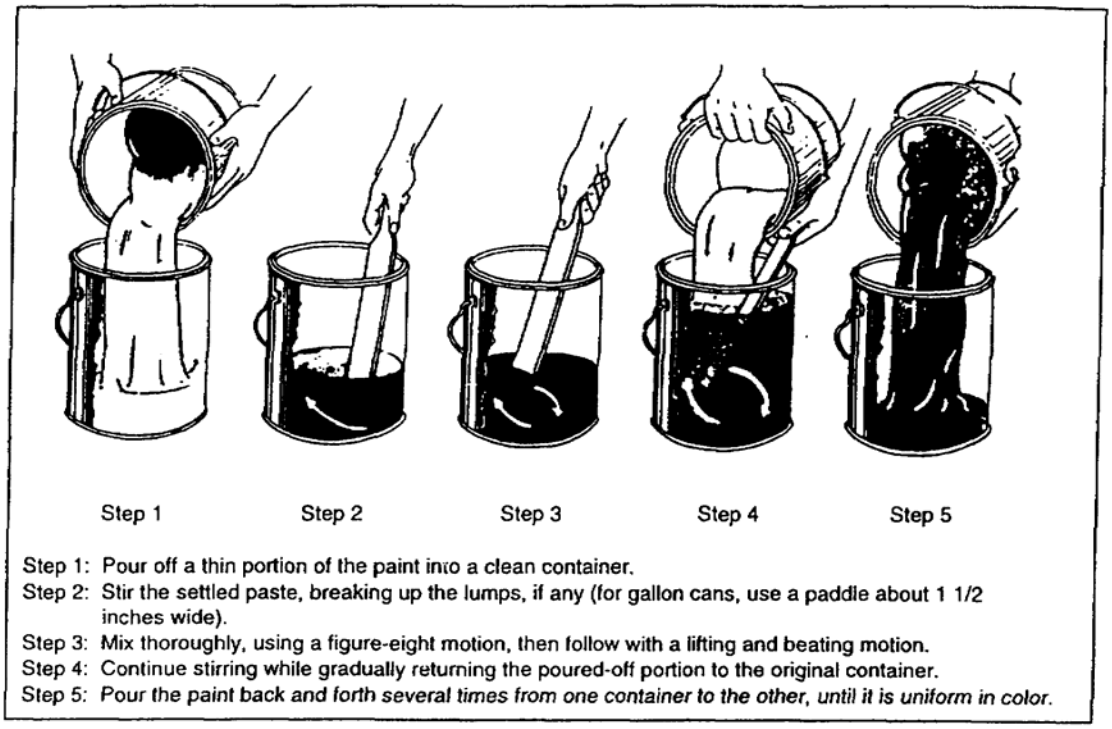

Figure 2-4. Boxing paint

(2) Using power-operated equipment. Power equipment that is normally used for stirring paints is the shaker or propeller type.

(a) Shaker-type mixers. Use shaker-type mixers to stir any type of primer or paint, but preferably those containing highly volatile thinners. These mixers can handle from 12 pint to 5 gallons, depending on the size of the machine. A typical shaker-type mixer is shown in Figure 2-5. These machines, which are generally electrically operated, blend paint materials by shaking them. The electric motor must be explosion-proof

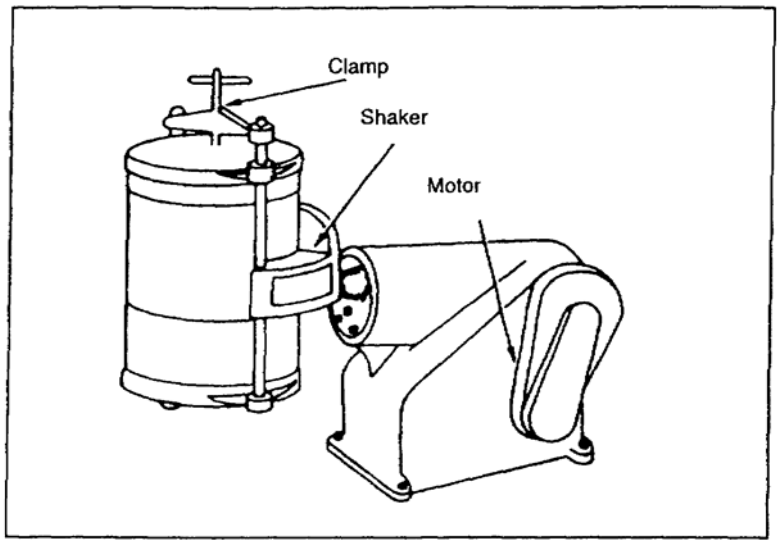

Figure 2-5. Shaker-type mixer

(b) Propeller-type mixers. Use the propeller-type paint mixers (Figure 2-6) to stir large quantities of primer and paint in open containers. Paint is agitated by the propellers or paddles attached to an electrically rotated shaft. The electric motor of this mixer must be explosion-proof.

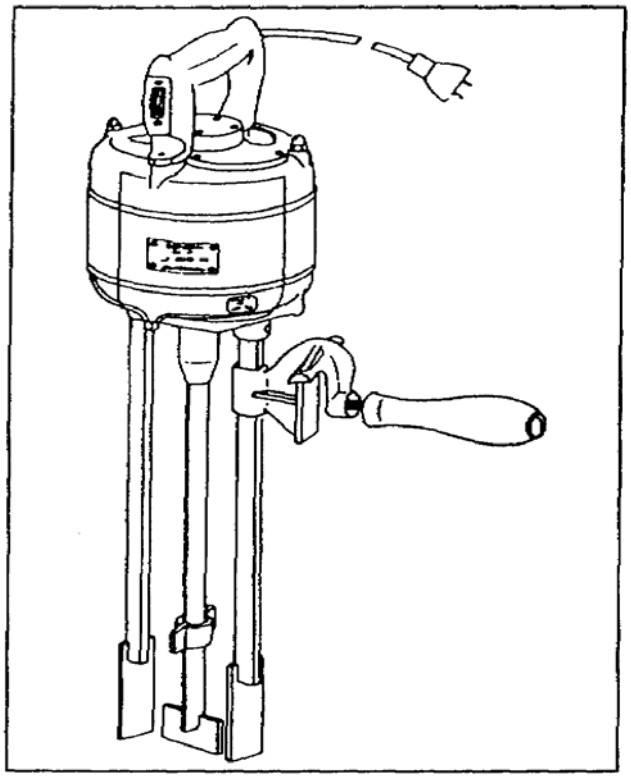

Figure 2-6. Propeller-type mixer

g. Thinning. Thinners and solvents have definite functions in coating materials; but for economic reasons, packaged products generally contain the smallest possible percentage of volatile material compared to solid. The resulting high consistency makes it necessary to thin packaged materials to varying degrees to suit the particular material, the application method, and the surface being coated. General rules for thinners and solvents are -

- Add thinner to the coating material. Adding coating material to thinner may result in an irreversible separation of some of the coating ingredients. To ensure complete mixing, you should add the thinner slowly to the coating material while stirring continuously.

- Use only the recommended thinner indicated on the paint-can label. The wrong thinner may destroy certain characteristics of the coating material that are not immediately evident in the wet state.

- Use caution and good judgment when thinning coating materials. Reduced material that has increased in viscosity due to evaporation will require corrective thinning. However, some coating materials which undergo chemical processes, such as polymerization, to create a film cannot be thinned beyond a certain point and remain usable. After the chemical action has progressed beyond a certain point, the coating material cannot be brought back to the correct viscosity.

- Determine the thinning required for a particular job by using good judgment and actual testing. Excessive thinning or insufficient thinning is detrimental to the normal flow characteristics of a coating. Excessive thinning leads to runs and sags, and insufficient thinning causes rough coatings. The amount of thinning used for spray application directly influences the evaporation rate of the volatiles passing from the paint gun to the surface; a major portion of the thinner can be lost en route. The cooling effect of this evaporation, plus the cooling due to expansion of the atomizing air, may lower the temperature of the coating material as much as 20°F below that of the surrounding air. The temperature of the deposited film may fall below the atmospheric dew point, and atmospheric water vapor will condense the film. For example, when air temperature is 70°F and the relative humidity is 70 percent, the dewpoint is 63°F or 7°F below the ambient temperature. At this point, the adhesion qualities of enamel may be reduced. The refrigerating effect will also affect the drying and the flow of quick-drying materials.

h. Aluminum-Pigment Mixing. To overcome the difficulties encountered when dispersing aluminum paste or powder pigments (lacquers and varnishes), follow these steps closely:

(1) Weigh and measure the amount recommended on the container.

(2) Place the weighed pigment in a clean container that is large enough to contain the entire mix and allow room for stirring. In a separate clean container, measure the volume of the vehicle to go with the pigment.

(3) Pour the vehicle into the pigment in small quantities; never add the pigment to the vehicle. Stir each quantity thoroughly before more vehicle is added. Use 10 percent in the first addition, 10 percent in the second, 20 percent in the third, and then add the remaining amount to the pigment. Stir thoroughly to ensure the complete wetting of the pigment.

(4) Box the material by pouring it from one container to the other several times.

(5) Strain the material through double- or triple-thickness cheesecloth to ensure that no lumps remain.

(6) Stir the material occasionally during application. Stirring should be moderate and only enough to keep the pigment in suspension. Too much agitation may cause darkening and the loss of leafing power. Prolonged storage of mixed aluminum-coating materials may also destroy leafing power, so carefully estimate the quantity to prepare.

PART C: PREPARING THE SURFACE

2-9. Surface Preparation. Good surface preparation is essential. Different surfaces, such as a nail hole in wood trim or cracks in a plaster wall, require different treatment and materials. Several materials are available to improve the surface before painting. They are undercoat, sealer, primer, size, wood filler, plastic wood, caulking compound, putty, texture paint, spackling compound, joint cement, and paint and varnish remover.

a. Undercoat. An undercoat is the coat applied prior to the finishing or the final coat. On old work, the undercoat is the first coat applied; on new work, the undercoat is applied after the primer and before the final coat. Undercoat is essential for its hiding power, and it provides a smooth surface for the final coat.

b. Sealer. A sealer fills the pores of absorbent surfaces in preparation for painting. By preventing the absorption of oil from the paint, a sealer reduces the number of coats of paint required and ensures a stronger film. Some sealers are used to protect the final coat from chemicals that are present in the surface. Sealers are usually applied as the first coat. There are many commercial sealers. One type that you can easily make is a mixture of shellac and alcohol. Reduce the shellac with alcohol, 4 to 1 if it is to be used over a filler and 7 to 1 if it is to be used over stain. Then, pour the mixture into an equal amount of lacquer to make a sealer.

c. Primer. A primer is a film-forming material used as the first coat of paint. It provides adhesion for the following coats and prevents undesirable chemical reaction to the surface. It may be a thinned first coat of paint or a specially prepared product. Different types of primers are available for different types of surfaces. Exterior wood primer, epoxy primer, phenolic-resin primer-sealer, wash primer, zinc-chromate primer, and metal primer are discussed below:

(1) Exterior wood primer. A wood primer is usually a thinned coat of the paint to be used or a specially prepared coat.

(2) Epoxy primer. An epoxy primer is a two-component pigment primer specially made to stick well and reflect heat. It is nonchalking, nongloss, and very resistant to chemicals, lubricants, and corrosive atmospheres. This primer is made primarily for spraying; however, you may brush it on small areas. Mix it by adding equal parts, by volume, of the pigmented primer to the catalyst just before using. Use epoxy primer within 10 hours after mixing. Because it is an epoxy, this primer is difficult to remove. There are several types of epoxy primers designed to be used on specific items. For this reason, you should follow the manufacturers recommendations when using them.

(3) Phenolic-resin primer-sealer. A phenolic-resin primer-sealer is a new type of finish that is well suited for open-grain woods. It penetrates into the pores of the wood, dries, and equalizes the density of the hard and soft grains. Staining and painting of wood thus treated eliminates light and dark streaks that are frequently present on untreated wood. This sealer is light amber in color and almost as thin as water. You can add pigment as well as color in oil to produce almost any color desired.

(4) Wash primer. The term wash primer designates a specific material that combines the properties of an inhibitive wash coat or metal conditioner with the properties of a conventional anticorrosive primer. The essential components of wash primers are phosphoric acid, zinc chromate pigment, and polyvinyl butyral resin. Wash primers can be formulated so that they are equally effective on iron, steel, aluminum, treated magnesium, copper, zinc, and a wide variety of other metals. Discard mixed primer after 8 hours. Many coatings adhere well to the wash primer, including oil-based alkyds, epoxies, and urethanes. Wash primers-

- Apply easily and dry rapidly.
- Are usable in wide ranges of temperatures and humidity levels.
- Can be applied to a variety of metals with good results.
- Provide temporary protection until a protective coating is applied.
- Prevent or retard corrosion development.
- Exhibit a high degree of adhesion to metals.
- Upgrade the performance of subsequent protective coatings.

(5) Zinc-chromate primer. Zinc-chromate primer is used in tremendous quantities by the armed forces. Its rust-inhibitive qualities prove very satisfactory. Do not use it in a straight linseed-oil vehicle but in a synthetic resin vehicles, such as phenolic resin or alkyd resin. For priming structural steel, the addition of some raw linseed oil is advantageous. Use zinc-chromate primer as a primer for metal surfaces, such as structural steel, bridges, tanks, refrigerators, railroad cars, motor vehicles, and aircraft.

(6) Metal primer. Pigments of lead and chromate are considered hazardous; as a result, two other primers have replaced red lead-based primer They are zinc-molybdate

primer and red iron-oxide, zinc-oxide, linseed-oil primer. These primers do not contain toxic lead or chromate pigments, but some corrosion protection has been sacrificed.

(a) Zinc-molybdate primer. Zinc-molybdate primer (alkyd type) is designed for use on steel (cleaned to a commercial-blast grade or better) and aluminum. This primer has low VOC content.

(b) Red iron-oxide, zinc-oxide, linseed-oil primer. This primer replaces red lead-based primer. It is designed for use on steel that has been cleaned with hand tools.

d. Size. Size is used to fill the pores of plaster or wallboard so that paint will stay on the surface. There are several types of size available, but the main types are glue-water and thinned varnish. Prepare varnish size by thinning 1 gallon of varnish with 1 quart of turpentine. Prepare glue-water size by mixing glue and water until the mixture will spread easily. Primers and sealers have been improved to the extent that size is seldom needed for paint preparation today.

e. Wood Filler. Wood filler provides a smooth, even finish on wood that has open grain, such as walnut, mahogany, and oak. Paste wood fillers are usually made of silex or silica ground in linseed oil and lacquer drier with various pigments added for color. Fillers come in standard colors, such as mahogany, light oak, dark oak, maple, walnut, black, white, and natural.

Most fillers come in paste form and are too thick to be used without thinning. Thin filler by adding turpentine, naphtha, or a special thinner according to the instructions on the container. About 12 pint of thinner to 1 pound of filler is required for coarse, open-grained woods. Closer grained woods, such as walnut, rosewood, mahogany, and zebrawood, require a mixture of about 10 ounces of thinner to 1 pound of filler. When you are mixing filler, add a little thinner at a time until you can get the desired consistency.

f. Plastic Wood. Plastic wood is used to fill holes in wood, especially if the finish is to be clear. It is available commercially and can be purchased in various quantities. This filler dries very rapidly and must be kept in airtight containers.

g. Caulking Compound. Caulking compound is used to seal joints around doors and windows and between baseboards and wallboards. It usually contains asbestos fiber, a pigment for opacity, fish or soybean oil, and a drier. Caulking compound will remain elastic for some time; this allows it to expand and contract with the movement of the building. There are two main types of caulking compound: the gun type, which is forced into cracks and crevices in ribbonlike form, and the knife type, which is applied with a putty knife. Caulking compound can also be used as a window-sash putty, and it is available in rolls or strips that are applied by pressing them into joints.

h. Putty. Putty is used to fill holes in surfaces and to replace checked or broken putty around windows. Commercial putty is made of white alkyd and whiting combined with linseed oil and a neutral oil to prevent it from drying too rapidly. Occasionally, you may substitute plastic wood for putty when filling holes in wood.

i. Texture Paint. Texture paint has a heavy consistency that is designed to produce a textured effect on a surface. Since it is thick and can be molded to obtain various decorative effects, it is particularly suitable for finishing sheetrock in drywall construction. You can make texture paint on the job by mixing joint cement with paint to obtain a butter consistency. Mix the color before applying the paint.

j. Spackling Compound. Spackling compound is a white powder. When mixed with water, it sets quickly without swelling or shrinking. Use spackling compound to apply a texture effect on smooth interior surfaces, such as plaster, sheetrock, wallboard, gypsum board, and primed and unprimed wood.

k. Joint Cement. Joint cement is used to fill depressions left by a hammer when nailing sheetrock. You may also use it with perforated tape to fill the recessed edges of sheetrock joints. Mix joint cement with water until a thick paste is formed, and apply it with a broad-blade putty knife or a cement trowel.

l. Paint and Varnish Remover. Paint and varnish remover is made of chemical solvents that are spread over the old finish to soften it so that it can be removed with a steel scraper, a putty knife, or steel wool. It is available in paste or liquid form; the liquid form is faster-acting.

PART D: SELECTING EXTERIOR AND INTERIOR PROTECTIVE COATINGS

2-10. Exterior Protective Coatings. You must consider the type of surface when selecting a protective coating for a particular job.

a. Types of Surfaces.

(1) Wood. When exterior wood surfaces are painted, you must decide whether the two-coat or three-coat system is to be used. Primer is not necessary when you repaint previously painted surfaces that are in good condition. For surfaces that have never been painted, use a primer coat, a body coat (undercoat), and a final (finish) coat. Alkyd-modified, oil-based paints and latex, water-based, exterior white paints (house paint) have replaced white oil-based paints. If a primer is required, use the type recommended by the manufacturer of the final coat of paint.

(2) Metal. Metal surfaces, such as galvanized iron, tin, and steel building materials, require protective coatings. Metal surfaces may rust if they are not protected against moisture. Copper does not rust, but it gives off a corrosive wash that discolors the metal. Aluminum does not rust, but it corrodes if it is unprotected. After applying the proper primer coat, apply conventional house paints (alkyd) or exterior latex to metal surfaces (other than copper). With the exception of metal roofing and copper, you may also use aluminum paint to paint metal surfaces.

(3) Masonry. A variety of paint products is available to coat masonry surfaces, such as brick, cement, stucco, cinder block, or asbestos cement. One of the newer ideas for painting brick is a clear coating that withstands weather, yet allows the natural

appearance of the surface to show through. You may also use cement-based paints, rubber-based coatings, and vinyl and alkyd paints on many types of masonry. You may apply almost all exterior house paints to masonry; however, you must prepare the surface properly. Good results are obtained by painting concrete porches and steps with a rubber-based coating or similar product. Roughening the surface slightly with muriatic acid is recommended before painting concrete that is hard and glossy. All concrete surfaces must be primed with an alkali-resistant primer.

b. Types of Exterior Coatings. Several of the most commonly used coatings for exterior surfaces are listed below. Notice that some are applied on exterior and interior surfaces. New paints are being developed each year, so you should read the latest literature and technical publications to keep abreast of new developments.

(1) White alkyd, latex, and acrylic paint. Alkyd paint is a glossy enamel that is compounded for use as a second or final coat on exterior wood or metal and on interior drywall or plaster. It offers heavy-duty protection for these surfaces. Alkyd paint also comes in a flat finish. Flat-latex and satin-gloss acrylic paints are formulated for most exterior building surfaces of wood, metal, and masonry. Most latex paints may be thinned slightly with water for spray application. For success with these paints, always use an alkyd or latex exterior primer. Some latex paints are self-priming if they are painted over previously painted wood surfaces that are in good condition.

(2) Masonry white latex (acrylic) paint. This paint is intended for exterior body or final coats on primed masonry surfaces (except floors). The paint, white or tinted, dries to a flat finish; so when a glossy finish is desired, you must use exterior glossy paints. Paint adheres poorly to glazed surfaces, so you must roughen such surfaces by acid-washing, sandblasting, or rubbing the glaze off with abrasive stones. It is unnecessary to remove old coatings, organic compounds, or cement-water paints that are firm. However, you must remove paint that is loose or flaking to ensure adhesion of the new paint. Since moisture is detrimental to exterior masonry paint, surfaces must be thoroughly dry before primer, body, and final coats are applied.

(3) Zinc-oxide oil or resin paint. A zinc-dust and zinc-oxide paint is manufactured to prime zinc surfaces. You may also use the paint for body and final coats. There are several types of this zinc primer. One type is an air-drying paint that has a linseed-oil vehicle. Another type, an enamel, has a glycerol-phthalate vehicle that causes the paint to dry faster. This enamel can be baked dry if necessary. Still another type, an enamel containing phenolic resin, is recommended for priming the inside surfaces of steel water tanks because the primer is nonpoisonous. Before using zinc primer on new surfaces, you must clean the surfaces with turpentine, mineral spirits, or another approved cleaner to ensure good adherence of the primer coat.

(4) Olive-drab oil-based paint. This exterior paint is suitable for use on wood, metal, and masonry that is exposed to the elements. It is a semigloss paint that has good color retention, and it is used for body and final coats.

(5) International-orange oil-based paint. This paint consists of two different types of paint, and it comes in two colors-chrome orange (color of a ripe tomato) and orange red. The most durable type of international-orange paint is chrome-orange-pigmented, linseed-

oil paint. It is a slow-drying paint used for body and final coats on exterior surfaces of large buildings. A small amount of spar varnish is included in the paint to retain color; however, the color still has a tendency to fade due to exposure.

International-orange enamel is the other type of international-orange paint and is similar in color to the above paint. It is not as durable; however, it holds its color much better and dries faster. The vehicle in the enamel is glycerol-phthalate synthetic enamel. The enamel is a vivid orange red, and it is very durable. The color is fast, and it looks best when applied over body coats of the same color. The enamel dries enough overnight to allow sanding and application of another coat. The enamel is recommended for body and final coats on small, metal surfaces.

(6) Chrome-yellow oil-based paint. This exterior paint is a durable, bright yellow paint that is applied as a final coat on wood, metal, and masonry. Use it primarily for painting towers and traffic signs. Significant names applied to tints of this paint are Highway-Marking Yellow, Army-Navy Aircraft Yellow, and War-Department Yellow.

(7) Rust-inhibiting, solvent-resistant drum enamel. This exterior enamel is used for coating metal drums and is an olive-drab, semigloss enamel. It is a one-coat enamel that contains glycerol-phthalate resin, and it dries fast.

(8) Aluminum-paint mixing varnish. A mixing varnish is contained in aluminum paint that is used for priming exterior wood and for general purposes. You may also use it for final coats on metal. Tung-oil varnish is used as the vehicle in aluminum paint for general use. Tung-oil varnish is one of two types of mixing varnish. If it is necessary to spray paint, 1 gallon of aluminum paint containing mixing varnish may be thinned with 1 pint of turpentine. In order to bring paint to the proper consistency, add aluminum paste when using mixing varnish of high viscosity and add aluminum powder when using mixing varnish of low viscosity.

(9) Asphalt varnish. This varnish is a general-purpose varnish that is used when covering water pipes, gas pipes, and so on. It is composed of asphalt mixed with drying oils, solvents, and driers. When dry, asphalt varnish has a smooth, glossy finish that is similar to glossy, black enamel.

(10) Water-resisting spar varnish. This is a durable covering for interior or exterior use. When dried, it has a softer film and less luster than some of the other oil-type varnishes.

(11) Clear and pigmented spraying lacquer. A spraying lacquer is either clear or pigmented. It is used over suitably primed metal and wood interior and exterior surfaces. For repaint jobs, apply a sealer or bleeder coat before the lacquer is sprayed over a color. Ordinarily, the spraying lacquer does not require thinning.

(12) Cold-water white paint powder and liquid. Exterior cold-water paint powder makes an inexpensive paint that dries to a porous film. It is breathing paint that is used on masonry surfaces where permeability and durability are important. The paint is also available in colors. You may often mix linseed oil and spar varnish with water to form the vehicle for exterior cold-water paint and to make the paint more durable; however, special

water-dispersible oils are on the market which effect better dispersal of the oil throughout the water. The paints resulting from either vehicle are equal in quality. Cold-water paint is applied to clean, masonry surfaces, such as concrete, brick, wet walls, and so forth. Masonry surfaces should be uniformly dampened (not wet) before the paint is applied. You may also use the paint on clean, primed wood or metal surfaces.

(13) Black oil-based paint. This paint is a glossy, slow-drying paint that is used for final coats on the surfaces of exterior wood, masonry, and structural steel. It is durable and has excellent hiding qualities when used on structural steel that has been primed and body-coated with two coats of rust-resistant paint.

(14) Black-graphite oil-based paint. This paint is used as body and final coats to cover primed surfaces of ferrous metals. The graphite in the paint has leafing properties that account for its durability. There are two types of graphite paint. One type is a steel-gray paint that has a metallic luster. Lampblack or carbon black is mixed with natural flake graphite, as well as other types of natural and artificial graphites, and is dark in color. Light-colored graphite paint is intended for body coats, and dark-colored graphite paint is designed for final coats.

(15) Iron-oxide red and brown oil-based paint. Exterior iron-oxide paint is manufactured in different colors of red and brown. It is an economical paint, and it is durable. Spar varnish and zinc oxide in the paint increase its color retention and decrease the paint's tendency to mildew. Iron-oxide paint is intended for use on roofs, barns, freight cars, and so forth. It may be used for body and final coats on metal, wood, and masonry. You can use this paint as a primer on structural steel, although it is not as satisfactory as a rust-resistant agent for ferrous metals.

(16) Aluminum. Aluminum paint is probably used for more jobs than any other paint. It is a desirable coating for battleships and large bridges, since the dried film weighs less than half as much as the film of any other common paint. It is used to cover and protect steel structures and buildings, because it is durable and light-colored. It reflects light and heat more than any other paint and has a desirable decorative finish. It is commonly used as a body and final application over a red iron-oxide, zinc-oxide, or linseed-oil priming coat.

Aluminum paint provides excellent service when applied in two or three coats, without priming paint, to clean and rust-free surfaces. When you paint steel, the importance of clean surfaces cannot be overemphasized. Aluminum paint is also used successfully for painting galvanized iron. Without a primer, the paint will bond satisfactorily with the galvanization if the metal has been exposed to the weather for at least 6 months. Aluminum paint possesses excellent durability when used as a priming coat for wood construction. It will cover soft, pitchy, and resinous spots very effectively. It also prevents the bleeding of wood stains. You may apply final coats of light-colored paint when the correct aluminum paint is used as an undercoat.

(17) Cement-based paint. This paint comes in powder form and is used on porous interior and exterior masonry surfaces (except gypsum plaster). There are two types of powder. One type has 80 percent portland cement and 10 percent hydrated lime. The second type has more hydrated lime and less portland cement than the first. Use the first

type for painting inside surfaces of swimming pools, water tanks, and so forth. Both types contain small percentages of titanium dioxide, zinc sulfate, water repellents, and calcium or aluminum stearate.

(18) Plastic paint. Plastic paint is another type of protective coating available on the market in recent years. The word plastic, as applied to paints, is an abused term. The fact that this word or some variation of it appears in a trade name does not necessarily mean the product has extraordinary properties. Any synthetic resin paint might be called plastic paint because the phenolic, vinyl, and other synthetic resins commonly used in paints are varieties of plastic, compounded with special grades of solution-type resins. True plastic coatings are now available, and some of the common ones are discussed below. These are tough, flexible coatings that are highly resistant to the natural elements and many chemicals. They are especially suitable on surfaces where most other coatings have been ineffective. With increased use and improved application methods, costs of plastic coatings are expected to decrease.

(a) Vinyl-resin plastics. Vinyl-resin plastics are being used as protective coatings. They include plastisols, organosols, and dry (generally powdered) vinyl resins. Plastisols are vinyl resins that are dissolved in liquid plasticizers, which remain chemically unchanged until heat-treated. Organosols are similar to plastisols, except small amounts of volatile solvents are added to improve the application properties. Both have a high solid content; and the plastisols are essentially 100 percent solids. The fusion of resins and plasticizers to form plastic film is caused by raising the temperature of the film between 300 and 360°F. These plastics are used to manufacture such items as dishwasher racks, dish drainers, plating tanks and racks, piping and vinyl-on-metal laminates for luggage, instrument cabinets, and furniture. Other plastics, such as cellulosic, acrylonitrile, and acrylic are being used as protective coatings. These are generally applied by heat processes when the dry resin is fused onto the surface to be protected. They are applied as temporary coatings to gears, shafts, screws, and other machine parts during shipment and storage.

(b) Plastic tapes. Plastic tapes are being used to protect steel pipe. Self-adhering plastic tapes and those requiring a primer are available. Polyethylene and polyvinyl-chloride tapes are the most common ones and are available in 10-, 12-, and 20-mil thickness (20 mils is 20 thousandths of an inch). You will generally use a wire brush to clean the surface, and a primer may be needed before you apply the tape.

(19) Floor and deck enamel. A paint with a varnish vehicle is, in reality, an enamel. It is intended for body and final coats on primed wood and concrete surfaces. It is an excellent, fast-drying, tough covering that is flexible enough to withstand wear and weather. To make self-primer for-

- A wood floor: Add 1 quart of thinning liquid (1 part turpentine or mineral spirits and 2 parts boiled linseed oil) to 1 gallon of floor-and-deck enamel. Body coats that you mix for wood floors should have 1 pint of boiled linseed oil added to each gallon of enamel. Apply the final coat as furnished in the container.

- A concrete floor: Add 1 quart of thinning liquid (1 part turpentine or mineral spirits to 2 parts of spar varnish) to each gallon of enamel. Apply body and final coats as furnished in the container.

(20) Bituminous (coal tar) or asphalt coating. This coating is used extensively as waterproofing, as roofing, and for protection of submerged and buried metal pipes and devices. It is applied at reasonable cost and makes a substantial barrier against attack by moisture and oxygen. Asphalt coating is available as an enamel, a cold-applied paint, and an emulsion. It is considered more resistant to the elements than coal tar.

(21) Waterproofing paint. Masonry is porous and soaks up water, causing damp interior walls, cracked plaster, and peeling wallpaper and paints. Silicone water-repellent paint will usually prevent this problem. With a single application (spray or brush), you will be able to provide an invisible water-repellent surface that will preserve the finish for 5 to 10 years. Oil-based and cement-based paints can be applied over the application. Oil-based paints will destroy the breathing characteristics of the masonry.

(22) Swimming-pool paint. Rubber-based paint is popular for painting swimming pools and other water-holding structures; however, water-mix cement-based and enamel paints with a water-resisting varnish vehicle of synthetic resin are popular. Recent developments have led to the use of epoxies, polyesters, and urethanes that have better resistance to water, chemicals, and abrasion than conventional coatings; but they are more expensive.

(23) Fungicidal paint. Fungicidal paint is used to preserve wood and fabrics by preventing rot. These paints are popular for foundation timbers, sills, fence posts, and farm buildings.

(24) Fire-retardant paint. Fire-retardant paint retards the spread of fire by a chemical action of the contents that tends to smother the fire.

(25) Camouflage paint. Camouflage paint has a dull finish, does not fade, is easily applied, is inexpensive, and covers in one coat. Camouflage paint is available in nine colors: light green, dark green, sand, field drab, earth brown, earth yellow, loam, earth red, and olive drab.

(26) Traffic paint. A ready-mixed traffic paint is known as centerline, zone-marking, and road-marking paint. It is available in white and yellow, and it is intended for application at a wide range of temperatures to bituminous and concrete highways bearing heavy traffic. Another type of traffic paint is one in which glass spheres are added when the paint is applied to the road surface. This semipaste form of paint, available in various colors, is called a pigmented binder. The glass beads serve as reflectors when automobile lights strike them at night.

(27) Whitewash. Whitewash is a lime paste mixed with water. The paint is inexpensive and used for covering interior and exterior wood or masonry surfaces. You primarily use it on brick, concrete, road or roadside obstructions (sidewalks, parking curbs, light posts), sheds, telephone poles, and so forth Make lime paste by slaking quicklime in enough water to make a stiff paste and allowing it to cure for several months. The mixing

ratios for two good lime pastes are: 20 pounds of quicklime to 10 gallons of water, and 50 pounds of hydrated lime to 6 gallons of water.

Two formulas for compounding whitewash are shown in Table 2-4. Notice that both formulas start out with the same weight of lime paste; however, the remaining materials and weights are different.

Table 2-4. Whitewash formulas

Material	Formula Number 1	Formula Number 2
Casein	5 pounds	
Trisodium phosphate	3 pounds	
Lime paste	8 gallons	8 gallons
Water	6 gallons	4 gallons
Common salt		12 gallons
Powdered alum		6 ounces
Molasses		1 quart

C. Recommended Exterior Coatings.

Table 2-5, pages 2-31 and 2-32, is a guide showing the type of coating recommended for various exterior surfaces. This chart is designed for general applications, and many times, variations must be made. The color selected for exterior surfaces should blend with other structures in the area. Color selection at an installation is often made by personnel other than protective-coating specialists.

Table 2-5. Recommended exterior coatings

Surfaces	House Paint (Alkyd)	Transparent Sealer	Cement-Based Paint	Aluminum Paint	Wood Stain	Roof Coating	Roof Cement
Clapboard siding	1-2	NA	NA	1	NA	NA	NA
Bricks	1-2	1	1	1	NA	NA	NA
Cement and cinder blocks	1-2	1	1	1	NA	NA	NA
Asbestos cements	1-2	NA	NA	NA	NA	NA	NA
Stuccos	1-2	1	1	1	NA	NA	NA
Natural wood siding and trims	NA	NA	NA	NA	1	NA	NA
Metal siding	1-2	NA	NA	1-2	NA	NA	NA
Wood-frame windows	1-2	NA	NA	1	NA	NA	NA
Steel windows	1-2	NA	NA	1-2	NA	NA	NA
Aluminum windows	1-2	NA	NA	1	NA	NA	NA
Shutters and other trims	1-2	NA	NA	NA	NA	NA	NA
Canvas awning	NA	NA	NA	NA	NA	NA	NA
Wood-shingle roofs	NA	NA	NA	NA	1	NA	NA
Metal roofs	1-2	NA	NA	NA	NA	NA	NA
Coal-tar, felt roofs	NA	NA	NA	NA	NA	1	1
Wood porch floors	NA	NA	NA	NA	NA	NA	NA
Cement porch floors	NA	NA	NA	NA	NA	NA	NA
Copper surfaces	NA	NA	NA	NA	NA	NA	NA
Galvanized surfaces	1-2	NA	NA	1-2	NA	NA	NA
Iron surfaces	1-2	NA	NA	1-2	NA	NA	NA

Legend:

1 = A primer or sealer is unnecessary before the finishing coat is applied.
1-2 = A primer or sealer may be necessary before the finishing coat is applied (unless the surface has been previously finished).
NA = This type of protective coating is not applicable for this surface.

Table 2-5. Recommended exterior coatings (continued)

Surface	Asphalt Emulsion	Trim and Trellis Paint	Awning Emulsion	Spar Varnish	Porch and Deck Paint	Primer or Under-coating	Metal Primer	Latex Paint
Clapboard siding	NA	NA	NA	NA	NA	1	NA	1-2
Bricks	NA	NA	NA	NA	NA	1	NA	1
Cement and cinder blocks	NA	NA	NA	NA	NA	1	NA	1
Asbestos cements	NA	NA	NA	NA	NA	1	NA	1
Stuccos	NA	NA	NA	NA	NA	1	NA	1
Natural wood siding and trims	NA	NA	NA	NA	1	NA	NA	NA
Metal siding	NA	1-2	NA	NA	NA	NA	1	1-2
Wood-frame windows	NA	1-2	NA	NA	NA	1	NA	1-2
Steel windows	NA	1-2	NA	NA	NA	NA	1	1-2
Aluminum windows	NA	1-2	NA	NA	NA	NA	1	1-2
Shutters and other trims	NA	1-2	NA	NA	NA	1	NA	1-2
Canvas awning	NA	NA	1	NA	NA	NA	NA	NA
Wood-shingle roofs	NA	NA	NA	NA	NA	NA	NA	NA
Metal roofs	NA	NA	NA	NA	NA	NA	1-2	1-2
Coal-tar, felt roof	1	NA	NA	NA	NA	NA	NA	NA
Wood porch floors	NA	NA	NA	NA	1	NA	NA	NA
Cement porch floors	NA	NA	NA	NA	1	NA	NA	1
Copper surfaces	NA	NA	NA	1	NA	NA	NA	NA
Galvanized surfaces	NA	1-2	NA	1	NA	NA	1	1-2
Iron surfaces	NA	1-2	NA	NA	NA	NA	1	1-2

Legend:

1 = *A primer or sealer is unnecessary before the finishing coat is applied.*
1-2 = A primer or sealer may be necessary before the finishing coat is applied (unless the surface has been previously finished).
NA = This type of protective coating is not applicable for this surface.

2-11. Interior Protective Coatings. There are many types of interior coatings available. These coatings are decorative and designed for use on certain types of surfaces.

a. Types of Surfaces.

(1) Wood. Alkyd paints for interior wood surfaces comes in flat, semigloss, and gloss paint finishes. Some paints come in tints as well as white. Alkyd enamels have a good hiding quality and flow smoothly. They offer durable to heavy-duty protection for wood, metal, drywall, and plaster. Latex paint is washable, and the finish may be gloss, semigloss, or flat. Some latex paints come in tints as well as white, and the tinted paints have a low-luster finish.

For interior woodwork that is to have a natural finish, you should prime and seal it with a ready-mixed varnish or spraying lacquer that is diluted with the recommended thinner. The varnish or lacquer is applied after the drying oil and filler have been put on and are dry enough to receive the primer-sealer. When interior woodwork is stained, shellac varnish is used as a primer-sealer to avoid the bleeding of aniline (synthetic organic dye) stains. You may use varnish or lacquer as a primer-sealer on other types of stains.

(2) Metal. When you paint interior metal surfaces, you should use a primer, at least one body coat, and a final coat. If more coats are applied, the additional coats are called body coats.

(3) Masonry. Interior masonry surfaces may be body-coated and final-coated with alkyd enamel or polyurethane paint that is used on wood or metal surfaces. Final coats are selected based on the color and the type of finish desired. For high-traffic areas, latex-based paints that will give a flat or an eggshell finish are available. When you desire a gloss or semigloss finish, you will generally resort to other alkyd enamels or latex paints.

b. Types of Coatings. Several of the most commonly used coatings for interior surfaces are listed below. Notice that some are used on exterior surfaces and interior surfaces. New paints are being developed all the time, and you should read current publications that deal with protective coatings.

(1) Interior cold-water white paint. This white paint comes in powdered form and is mixed with cold water. The paint is available in white and tints. This paint is primarily intended to cover primed, wet (damp) walls and other masonry surfaces. It is not satisfactory for surfaces that are continually damp because of its susceptibility to mildew. When repainting surfaces, you must remove calcimine and loose or powdering oil-paint coatings.

(2) Primer-sealer floor lacquer. This lacquer is intended for sealing clean, wooden floors that have been sanded. By sealing a newly sanded, close-grained or open-grained floor, you help fill the wood pores and provide a good foundation (priming coat). The primer-sealer reduces the tendency of the finished surface to mar, integrates the filler and the wood, and smoothes the surface.

(3) Fume- and heat-resistant white enamel. This enamel is used in chemical laboratories, dairies, refrigerator rooms, sewage-disposal plants, and areas subjected to

temperature or fumes. To avoid discoloration, the paint must be free from lead and iron. This enamel consists mostly of light-proof lithopone, titanium, zinc oxide, or a mixture of these pigments. The vehicle must exclude any metallic-compound driers but should include linseed, tung, soya, or other drying oils, along with damar, resin, and turpentine or mineral spirits. Use a softener, such as pine oil, to plasticize the paint. Fume- and heat-resistant white enamel will stand some tinting, particularly light gray, without discoloring under adverse conditions. The enamel is not as flexible as other white enamels and is less water-resistant than some of the quick-drying enamels.

(4) Flat white alkyd or latex enamel. This interior enamel is odorless and comes in tints as well as white. Latex flat wall paint is washable and may be applied to prepared walls and ceilings, wood trim, wallboard, primed plaster, brick, and masonry. Latex flat paint comes in white and eggshell.

(5) Semigloss white alkyd or latex enamel. This interior enamel may be used when a tough, durable, washable finish is needed (without the shine of gloss). The enamel also comes in a variety of tints.

(6) Gloss white alkyd or latex enamel. This enamel paint may be used on almost any interior wood, metal, drywall, or plaster surface.

(7) Polyurethane enamel white paint base. This interior paint base comes in white or tinted enamel. Polyurethane enamel is a water-based formula intended for making paints to be used on interior wet or dry walls, woodwork, trim, house and deck furniture, cabinets, and crafts. Polyurethane enamel is lead-free, solvent-free, nonflammable, has low odor, and dries to touch in 30 minutes. Use the paint on suitably primed wood and metal surfaces. The object to be body- and final-coated with resin-emulsion paint must be clean; and in case of a repaint job, the old paint must be firm or be removed from the surface. The paint is an oil-in-water emulsion product. Although you can apply it by any convenient painting method, it can be thinned only with water. The paint dries sufficiently hard overnight to be recoated. Directions for mixing with water are often placed on the container, and you should follow them.

(8) Concrete-floor, rubber-based paint. A rubber-based paint is made for use on interior concrete floors that are subjected to dampness and not exposed to sunlight. When used as a primer coat, you should mix 1 pint of mineral spirits and 1 pint of toluol (commercial grade) with 1 gallon of paint. You apply body and final coats as furnished in the container.

(9) Cold-water white paint. This interior paint comes in tints as well as white. It is intended primarily for covering primed wet wall and other masonry surfaces. It is not satisfactory for surfaces that are continually damp because of its susceptibility to mildew. You must remove calcimine and loose or powdering oil-paint coatings from surfaces being repainted.

(10) Heat-resistant black enamel. This enamel is manufactured for use on steam pipes and boiler fronts where temperatures of 400°F or higher are common. The objects you paint should be cooled below 140°F before paint is applied, and they should be held at this temperature for at least 48 hours before being subjected to a higher temperature.

Painting with enamel indoors is dangerous, so paint in well-ventilated areas and away from lights or flames. There are two types of heat-resistant black enamel for metal. One type has a bituminous base that is otherwise unpigmented. The other type has a resin base and is pigmented; it is also gasoline- and water-resistant.

(11) Luminous paint. Luminous paint is used to make areas glow with a brilliance. In dangerous areas throughout a building, it will act as a safety guide and show danger areas even after the lights are out. It is similar to the dial and hands on a luminous watch.

(12) Wax. Wax is available in paste, emulsion, and liquid. It is an important part of the finishing process, especially on furniture and floors. Wax is normally applied over varnish or shellac to protect the coated surface. You often apply it directly over sealer to provide a waterproof coating.

(13) Linseed oil. Linseed oil, as previously explained in this lesson, may also be used as a finish for wood surfaces. You ordinarily apply it by rubbing.

(14) Spirit varnish. Spirit varnish is a substitute for shellac varnish and may be used on interior wood, metal, paper, and fabric surfaces. You may substitute it for oil varnishes where rapid drying is more important than durability. This varnish is almost equivalent to shellac varnish, and you can brush or spray it on. It cannot be satisfactorily mixed with oil-based paints, oil varnishes, lacquers, turpentine, or mineral spirits.

(15) Shellac varnish. Shellac varnish is used primarily as a sealer and primer for interior wood and masonry surfaces. Although it is not as durable in some ways as oil varnishes, some painters use it for body and final coats. Occasionally, you will use it on exterior wood surfaces that are not directly exposed to the weather.

Shellac varnish is either white (bleached) or orange and is available in light-, medium-, and heavy-bodied consistencies. Shellac varnish comes in two grades. One grade is light in color and is practically free of resin and suspended matter. The other grade is dark in color and contains some insoluble matter; therefore, this shellac varnish is used where darker color and some resin are not objectionable. One thinner for shellac varnish consists of 5 parts methyl alcohol to 100 parts ethyl alcohol. Another thinner consists of 1 part aviation gasoline, 5 parts denatured ethyl acetate, and 100 parts denatured alcohol.

(16) Orange shellac. Orange shellac is used to make shellac varnish. Several grades of orange shellac are on the open market. The highest grades are known as superfine and other names. The second highest grade is resin-free and darker than the higher grades. The lowest commercial grade contains some resin. This grade is darker in color than the two highest grades.

(17) Damar varnish. Damar varnish is a spirit made to use as a final coat on interior surfaces. It is also used by manufacturers as a vehicle for some white and tinted enamels used for covering interior metal surfaces, such as radiators, that are exposed to high temperatures. It is not satisfactory for surfaces exposed to moisture and abrasion.

(18) Primer-sealer floor varnish. This varnish is used for treating wood and cork floors. It furnishes a good foundation for wax and other coats of varnish, and it helps fill open-grained wood. There are two classes of this varnish. One class is made for use on close-grained woods, and the other is made for use on open-grained, filled woods. Primer-sealer floor varnish is actually spar varnish that is thinned with turpentine or mineral spirits. When cut with thinner equal to one-half its volume, the mixture is similar to the class of primer-sealer varnish made for open-grained wood. When cut with equal amounts of thinner, the mixture is about the same consistency as the primer-sealer varnish made for close-grained woods.

(19) Interior varnish. Interior varnish is manufactured to use on inside woodwork and floors, except where the varnish is required to have rubbing qualities.

(20) Interior cabinet rubbing varnish. This varnish is intended for use on interior wood surfaces where a rubbed finish is desired. It is not a baking varnish for metal, nor is it a suitable varnish for floors.

c. Recommended Interior Coatings.

Table 2-6, pages 2-37 and 2-38, is a guide showing the type of coating recommended for various interior surfaces. This chart is designed for general applications, and many times, variations must be made. It is always wise to read the label on the container to ensure that the coating is compatible with the surface and primer being used.

Table 2-6. Recommended interior coatings

Surface	Semigloss Paint	Flat Paint	Casein	Interior Varnish	Shellac	Wax (Liquid or Paste)	Wax Emulsion
Plaster wallboards and ceilings	1-2	1-2	1	NA	NA	NA	NA
Wood paneling	1-2	1-2	NA	1	1	1	NA
Kitchen/ bathroom walls	1-2	NA	NA	NA	NA	NA	NA
Wood floors	NA	NA	NA	NA	1	1	1-2
Concrete floors	NA	NA	NA	NA	NA	1-2	1-2
Vinyl/rubber-tile floors	NA	NA	NA	NA	NA	1	1
Asphalt-tile floors	NA	NA	NA	NA	NA	NA	1
Linoleum	NA	NA	NA	NA	1	1	1
Stair treads	NA	NA	NA	NA	1	NA	NA
Stair risers	1-2	1-2	NA	1	1	NA	NA
Wood trims	1-2	1-2	NA	1	1	1	NA
Steel windows	1-2	1-2	NA	NA	NA	NA	NA
Aluminum windows	1-2	1-2	NA	NA	NA	NA	NA
Window sills	NA	NA	NA	1	NA	NA	NA
Steel cabinets	1-2	1-2	NA	NA	NA	NA	NA
Heating ducts	1-2	1-2	NA	NA	NA	NA	NA
Radiators and heating pipes	1-2	1-2	NA	NA	NA	NA	NA
Old masonry	1	1	1	NA	NA	NA	NA
New masonry	1-2	1-2	NA	NA	NA	NA	NA

Legend:

1 = A primer or sealer is unnecessary before the finishing coat is applied.
1-2 = A primer or sealer may be necessary before the finishing coat is applied (unless the surface has been previously finished).
NA = This type of protective coating is not applicable for this surface.

Table 2-6. Recommended interior coatings (continued)

Surfaces	Stain	Wood Sealer	Floor Varnish	Floor Paint or Enamel	Aluminum Paint	Sealer or Under-coat	Metal Primer	Latex Paint
Plaster wallboards and ceilings	NA	NA	NA	NA	NA	1	NA	1
Wood paneling	1	1	NA	NA	NA	NA	NA	1-2
Kitchen/ bathroom walls	NA	NA	NA	NA	NA	1	NA	NA
Wood floors	1-2	1-2	1-2	1-2	NA	NA	NA	NA
Concrete floors	1	NA	NA	1	NA	NA	NA	1
Vinyl/rubber-tile floors	NA	NA	NA	NA	NA	NA	NA	NA
Asphalt-tile floors	NA	NA	NA	NA	NA	NA	NA	NA
Linoleum	NA	NA	1	1	NA	NA	NA	NA
Stair treads	1	1	1	1	NA	NA	NA	NA
Stair risers	1	1	NA	NA	NA	NA	NA	NA
Wood trim	1	NA	NA	NA	NA	1	NA	1-2
Steel windows	NA	NA	NA	NA	1	NA	1	1-2
Aluminum windows	NA	NA	NA	NA	1	NA	1	1-2
Window sills	NA	NA	NA	NA	NA	NA	NA	NA
Steel cabinets	NA	NA	NA	NA	NA	NA	1	NA
Heating ducts	NA	NA	NA	NA	1	NA	1	1-2
Radiators and heating pipes	NA	NA	NA	NA	1	NA	1	1-2
Old masonry	NA	NA	NA	NA	1	1	NA	1
New masonry	NA	NA	NA	NA	NA	1	NA	1

Legend:

1 = A primer or sealer is unnecessary before the finishing coat is applied.
1-2 = A primer or sealer may be necessary before the finishing coat is applied (unless the surface has been previously finished).
NA = This type of protective coating is not applicable for this surface.

PART E: MAINTAINING PROTECTIVE COATINGS

2-12. Efficient and Safe Handling, Storing, and Disposing of Protective Coatings. You must know how to handle, store, and dispose of protective coatings efficiently and safely. Proper knowledge of these duties will prevent overage stocks, the opening of wrong containers, and incompatible paint jobs. Furthermore, you can prevent accidents and injuries by learning safe disposal methods.

a. Handling. When handling paint containers, be careful not to damage the labels. Paint labels have valuable information on them, such as the date the paint was manufactured, its color, and its type. Without this information, you could waste or misuse large amounts of paint. If the labels are damaged, you should replace them with the correct information.

b. Storing. If possible, store protective coatings in dry, fire-resistant, well-drained, and well-ventilated structures, preferably separate from other buildings and under automatic-sprinkler protection. In addition-

- Avoid using space heaters and other direct-fired heaters in storage areas.
- Ensure that storage areas have concrete floors that are drained to one point. The drain should run to a sump or a detached cistern and have a deep trap.
- Ensure proper ventilation to allow paint fumes to escape. Place screened inlet air vents 6 inches above the floor and screened outlet air vents through the roof.
- Prevent paint containers from getting wet by protecting them from rain, snow, steam leaks, or other sources of water.

(1) Indoor heating. To avoid direct heat on the materials, do not store them near steam lines or other sources of heat. Use steam heat with heating coils above the stock and screen the coils to prevent them from contacting the containers. Do not store paint on floors below grade (ground level). Lay the first tier of containers on pallets that are at least two inches above floor level to allow suitable ventilation and drainage.

(2) Outdoor storage. Paints and paint thinners packaged in 55-gallon steel drums may be stored outdoors; however, the drums must be protected against rusting. Paint the bare metal areas and set the drums on dunnage (scrap lumber) to provide approximately 2 inches of clearance above the ground. Lay drums on their sides to prevent the loss of the markings stenciled on their heads. This also protects the drums against the weathering action of rain, snow, and sun.

(3) Indoor storage. Store paints and paint thinners separately from other materials such as grease, oil, and spare parts.

NOTE: Rags, wood, and similar combustible material must not be stored in the same building with paint.

(4) Accessibility. Ensure that containers of paint materials are readily accessible at all times. Do not stack other materials on top of paint materials. In addition, you should--

- Store and issue containers in the order of the manufacture date shown on the labels.
- Use material bearing the oldest date first. If the manufacture date is not shown on the container, you may consider the date of receipt as the approximate manufacture date for purposes of storage and issue.

(5) Temperature. For best results, the temperature of paint materials should be between 65 and 85°F (room-temperature range) at the time of use. If storage conditions result in paint temperatures being below 55°F or above 95°F, you should store the container at room temperature for approximately 24 hours before use.

(6) Internal pressure. Containers of paint may develop internal pressure from high temperatures. For safe release of internal pressure, use the following precautions:

(a) Internal pressure is apparent as bulging in light-gauge tin containers, but it is not evident in heavy-gauge steel drums. Use care when opening containers so that you allow the pressure to dissipate slowly before the seal is completely removed. If you fail to observe this precaution, you may be spattered with paint that explodes because of a sudden release of pressure.

(b) Open containers sealed with bungs by turning out the bung slowly until a hissing sound is heard. When the hissing ceases, indicating equalization of pressure with the atmosphere, the bung can be completely removed.

(c) Containers that are bulged or misshapened from internal pressure should have a small hole punctured in the top to release the pressure. Use a fine, nonspark producing tool, such as aluminum or copper. After correcting the bulged or misshapened containers, post signs on the storage building that read: FLAMMABLE-KEEP FIRE AWAY.

c. Disposing. Dispose of paints and chemicals when they become old, dried out, or contaminated with foreign matter. Take them to a sanitary fill, open the containers, and toss them into the fill. When acids become contaminated or have served their purpose, bury them about 2 feet deep in a designated disposal area. Remember, chemicals are dangerous; therefore, follow all directions and procedures when you use or dispose of them.

LESSON 2

PRACTICE EXERCISE

The following items will test your grasps of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answer with the key that follows. If you answer any item incorrectly, study again that part which contains the portion involved.

1. Which of the following coatings is not a serviceable exterior protective coating?

   A. Damar varnish
   B. Spar varnish
   C. Oil-based paint
   D. Rubber-based paint

2. Why do you add driers to protective coatings?

   A. To hasten film-hardening
   B. To protect the pigment
   C. To keep the pigment in the solution
   D. To increase viscosity

3. You are making aluminum paint from aluminum powder. You mix the powder according to formula, with _____.

   A. Glue
   B. Water
   C. Varnish
   D. Shellac

4. Fluids that evaporate rapidly are

A. Driers
B. Solvents
C. Volatiles
D. Nonvolatiles

5. You want to waterproof a concrete-block wall. For this purpose, the best base paint is

A. Silicone
B. Oil
C. Lacquer
D. Varnish

6. You have been assigned the job of painting a large, steel bridge. Which of the following do you apply?

A. Aluminum paint and red iron-oxide, zinc-oxide, linseed-oil primer
B. Zinc chromate and deck enamel
C. Aluminum paint and water emulsion
D. Red iron-oxide, zinc-oxide, linseed-oil primer and asphalt varnish

7. Which of the following would you select to provide a smooth, even finish on open-grained wood?

A. Size
B. Phenolic-resin primer-sealer
C. Texture paint
D. Wood filler

8. The label on a paint can states the color and the type of paint and which of the following items?

A. Viscosity
B. Date of manufacture
C. Consistency
D. Blending characteristics

9. Tints are lighter than _____.

A. Shades
B. Tones
C. Hues
D. Chromas

10. You are painting a previously painted, wood surface that is in good condition. The primer is _____.

A. Added to the undercoat
B. Added to the sealer
C. Thinned
D. Not necessary

11. You are painting a wood wall that has an absorbent surface. Which of the following would you apply before starting to paint?

A. Shellac and alcohol
B. Stain
C. Aluminum pigment
D. Zinc oxide

12. For best results, the temperature of paint materials should be between which of the following?

A. 45 and 55°F

B. 55 and 65°F

C. 65 and 75°F

D. 65 and 85°F

13. You want to mix 5 gallons of paint that contains a highly volatile thinner. What mixing method do you use?

A. Boxing

B. Paddling

C. Propeller

D. Shaker

14. You must paint walk stripes in a building. These stripes must glow in the dark.. Which of the following do you use?

A. Aluminum paint

B. Highway-yellow paint with glass beads

C. Luminous paint

D. Titanium dioxide

15. Zinc-oxide oil is a desirable primer for the inside of a water tank because it

A. Admits ultraviolet light

B. Is nonpoisonous

C. Is white

D. Is fast-drying

16. Which of the following tools would you use to apply joint cement to a sheetrock joint?

A. Float
B. Chisel
C. Putty knife
D. Screwdriver

17. When selecting a can of paint from the storeroom, you pick the can that _____.

A. Has the lowest temperature
B. Is on the top of the stack
C. Has the oldest manufacture date
D. Has no stirring requirements

18. What do you use as a primer on a steel bridge?

A. Zinc chromate
B. Epoxy
C. Phenolic resin
D. Hot alkyd varnish

LESSON 2

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer	
1.	A.	Damar varnish is a spirit made to use as a final coat on interior surfaces. It is not satisfactory for surfaces exposed to moisture and abrasion. (page 2-35, para 2-11b[17])
2.	A.	Driers are catalytic agents. They hasten film hardening when added to a drying oil or a paint or varnish that contains oil. (page 2-8, para 2-6b[2] [a])
3.	C.	An average formula mix for the production of aluminum paint is 2 pounds of aluminum powder or paste to 1 gallon of mixing varnish. (page 2-6, para 2-5c [1])
4.	C.	A volatile fluid is a substance that evaporates rapidly at relatively low temperatures. (page 2-2, para 2-1, Volatile)
5.	A.	Masonry is porous and soaks up water, causing damp interior walls, cracked plaster, and peeling wallpaper and paints. Silicone water repellent will usually prevent this problem. (page 2-29, para 2-l0b[21])
6.	A.	Aluminum paint is probably used for more jobs than any other paint. It is a desirable coating for battleships and large bridges, since the dried film weighs less than half as much as the film of any other common paint. It is commonly used as a body and final application over a red iron-oxide, zinc-oxide, or linseed-oil priming coat. (page 2-27, para 2-10b[16])
7.	B.	A phenolic-resin primer-sealer is a new type of finish that is well suited for open-grain woods. It penetrates into the pores of the wood, dries, and equalizes the density of the hard an soft grains. (pages 2-22, para 2-9c[3])
8.	B.	Paint labels have valuable information on them, such as the date the paint was manufactured, its color, and its type. Without this information, you could waste or misuse large amounts of paint. (page 2-39, para 2-12a)
9.	C.	Tints are lighter than hues and are formed by adding white to the colors on the color wheel. (page 2-15, para 2-8b)
10.	D.	Primer is not necessary when you repaint previously painted surfaces that are in good condition. (page 2-24, para 2-10a[l])

11. A. There are many commercial sealers. One type that you can easily make is a mixture of shellac and alcohol. (page 2-21, para 2-9b)

12. D. For best results the temperature of paint materials should be between 65 and 85°F (room-temperature range) at the time of use. If storage conditions result in paint temperatures being below 55°F or above 95°F, you should store the container at room temperature for approximately 24 hours before to use. (page 2-40, para 2-12b[5])

13. D. Use shaker-type mixers to stir any type of primers or paint, but preferably those containing highly volatile thinners. (page 2-18, para 2-8e[21 [a])

14. C. Luminous paint is used to make areas glow with a brilliance. In dangerous areas throughout a building, it will act as a safety guide and show danger areas even after the lights are out. (page 2-35, para 2-llb[11])

15. B. Zinc-oxide oil or resin paint. Still another type, an enamel containing phenolic resin, is recommended for priming of the inside surfaces of steel water tanks because the primer in nonpoisonous. (page 2-25, para 2-10b[3])

16. C. Joint cement. Mix joint cement with water until a thick paste is formed, and apply it with a broad-blade putty knife or a cement trowel. (page 2-24, para 2-9k)

17. C. Use material bearing the oldest date first. If the manufacture date is not shown on the container, you may consider the date of receipt as the approximate manufacture date for purposes of storage and issue. (page 2-40, para 2-12b[4])

18. A. Use zinc-chromate primer as a primer for metal surfaces, such as structural steel, bridges, tanks, refrigerators, railroad cars, and motor vehicles, and aircraft. (page 2-22, para 2-9c[5])

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LESSON 3

PROTECTIVE-COATING EQUIPMENT

OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn about the operation, maintenance, and storage of equipment that is used in applying protective coating.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will describe the operation, maintenance, and storage of painting equipment.

CONDITION: You will be given the material contained in this lesson.

STANDARD: You must complete the lesson and the practice exercise.

REFERENCES: The material contained in this lesson was derived from the TM 5-800 series, TM 5-618, EM 1110-2-3400, TB MED 502, AFI 48-101, TO 00-25-232, MIL-STD 1212, and NFPA 101.

INTRODUCTION

To perform as a painter, you must understand the operation, maintenance, and storage requirements used to accomplish your painting mission. As an operator of any piece of equipment, it is equally important for you to maintain that equipment. Without quality maintenance, equipment breakdowns can lengthen a project's duration or cause unnecessary delays.

PART A: SURFACE-PREPARATION EQUIPMENT

Before you apply any protective-coating material, it is important to prepare the work surface. If the surface is scaly, dirty, oily, or dusty, the coating will not adhere satisfactorily.

3-1. Hand-Operated Tools: There are numerous hand-operated tools; however, only the tools you are most likely to use in your work will be discussed in this lesson.

a. Wire Brushes. Hand wire brushes (Figure 3-1, page 3-2) are used to remove loose paint from wood, masonry, or metal surfaces that are situated in close places and where power equipment cannot be operated economically. The brushes are made of different sizes

and shapes depending on the stiffness required. Brush bristles are small- or large-gauged wires made of steel, brass, or stainless steel. Use steel wire bristles on steel, wood, and masonry; brass wire bristles on brass; and stainless-steel wire bristles on stainless steel. To prevent damage, store wire brushes by hanging them on a wall.

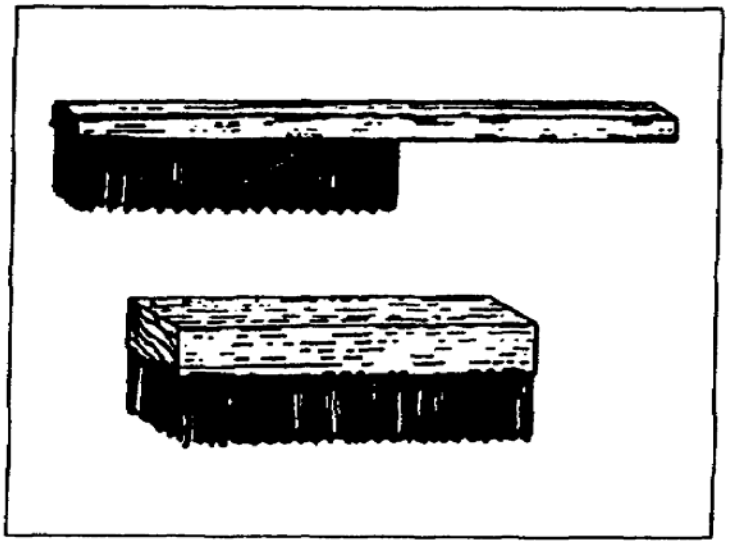

Figure 3-1. Hand wire brushes

b. Painter's Dusters. Painter's dusters are used to remove fine dust before painting. Dusters are usually flat or oval in shape and are fitted with handles similar to those on paintbrushes. Store painter's dusters by hanging them on a wall or by wrapping paper around them and laying them flat. Never stand dusters on their bristles.

c. Scrapers. Paint scrapers are grouped as pull, push, or molding (Figure 3-2). Scrapers will vary based on their intended uses; for example, one scraper type is used to remove deteriorated paint from the surface, and another is used to remove plane and mill marks from wood surfaces (Figure 3-3). Scrapers made of flexible steel must be kept sharp to do good work. Figure 3-4, page 3-4, demonstrates how hand-scraper edges are sharpened. The cutting edges of a cabinet scraper (Figure 3-5, page 3-5) and a scraper plane (Figure 3-6, page 3-5) are sharpened similarly to the hand scraper. You should never toss scrapers into a toolbox with other tools as this will nick the sharp edges and make it necessary to resharpen them.

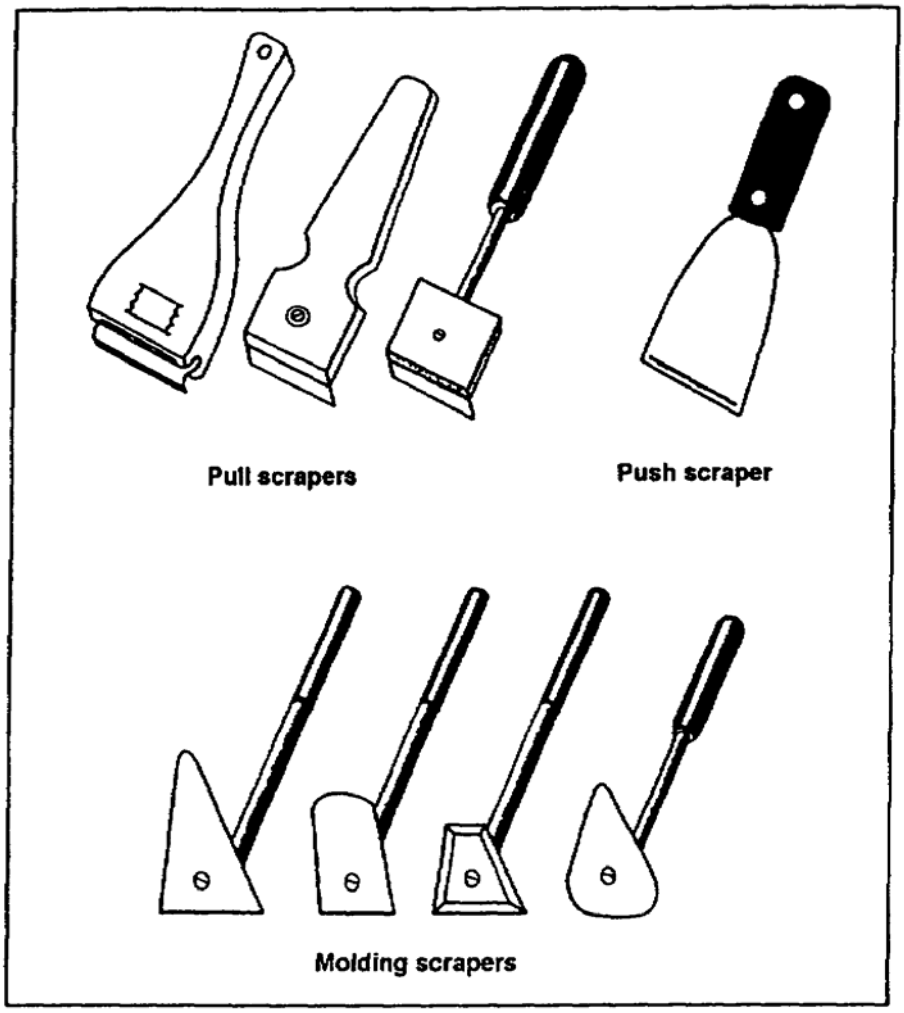

Figure 3-2. Pull, push, and molding scrapers

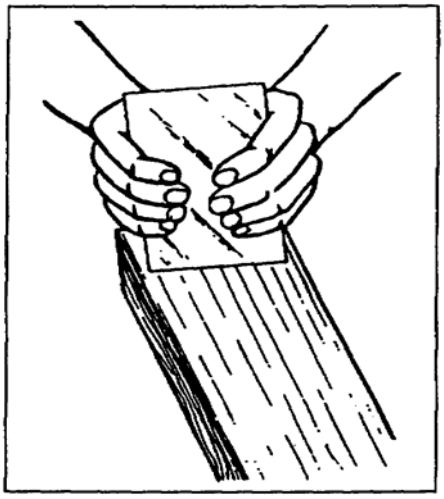

Figure 3-3. Wood scraper

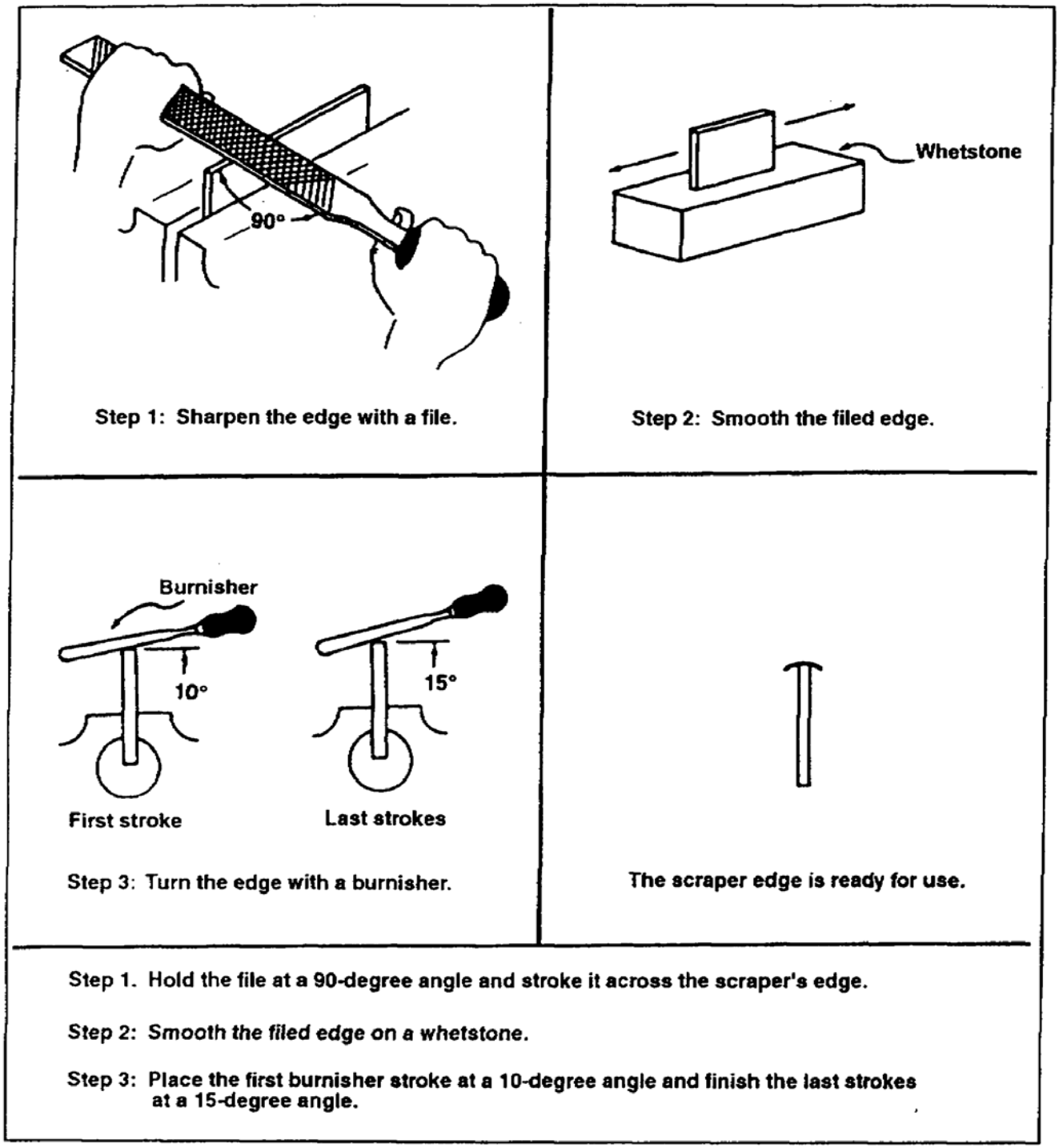

Figure 3-4. Sharpening hand-scraper edges

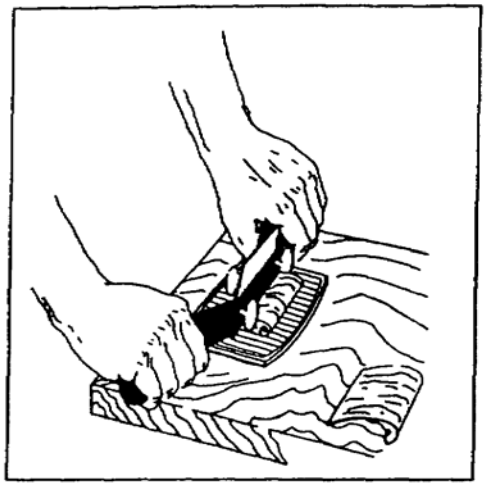

Figure 3-5. Cabinet scraper

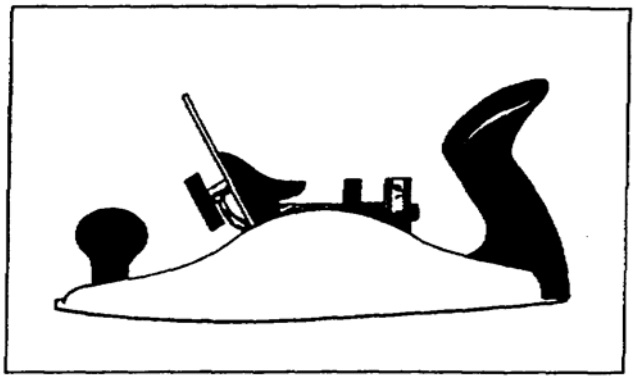

Figure 3-6. Scraper plane

d. Putty Knives. Among the many different putty knife styles available (Figure 3-7), there are those with short, stiff blades; long, flexible blades; wide blades, and narrow blades. The original purpose of putty knives was to gaze window panes into window frames, but they are often used to scrape old paint surfaces and apply joint cement to sheetrock walls. Putty knives seldom need sharpening, but they should be stored in a manner to prevent damage to the blades.

e. . Cold Chisels. Cold chisels (Figure 3-8) are used to chip paint or scale from metal surfaces, and the chisels are available in different widths and lengths. Chisels are sharpened by grinding their heads on a grinding wheel to restore the bevel, which is usually at a 60- to 70-degree angle. Occasionally, you may need to remove the burrs from the heads if the heads have mushroomed.

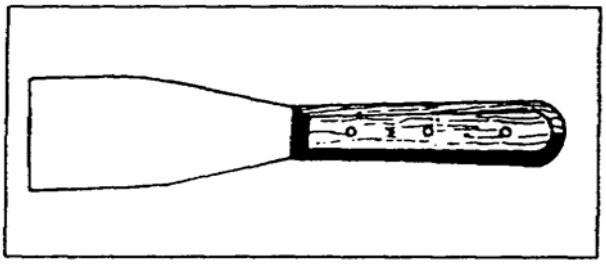

Figure 3-7. Putty knife

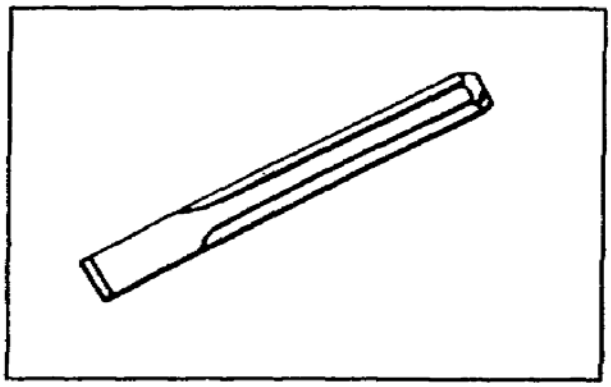

Figure 3-8. Cold chisel (3/4 inch)

f. Files. Files are steel tools used for cutting and smoothing metal and wood. A wood rasp is a course file that differs from the ordinary file in teeth shape and size. There are over 3,000 types and kinds of files and rasps. The most common types are shown in Figure 3-9. Clean files with a file card, which is a wood handle with a brush on one side and fine-wire teeth on the other. Preserve the sharpness of files and rasps by storing them in a rack. If you need to carry files in a toolbox, wrap them individually in cloth or paper to protect their teeth. To prevent rusting, keep files dry and do not use rust-preventive compound on them. Files are very brittle, so do not hammer files or use them as pry bars.

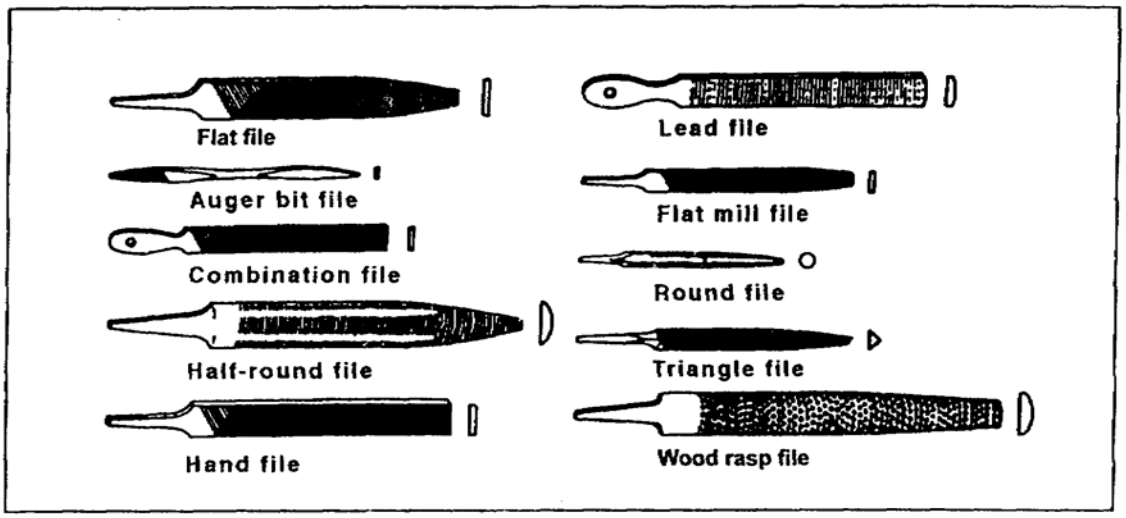

Figure 3-9. Files

g. Abrasives. There are many different abrasive types, and each type varies in grit, size, and use. Among the abrasive types available are-

- Flint is frequently used because of its low cost, but it dulls and wears quickly.
- Garnet is a natural mineral, and it is the choice abrasive for hand-sanding and wood-finishing.
- Emery is a natural mineral that comes from Turkey or Greece. It is a good cutting agent, but it abrades slowly. Emery is primarily used for metal-polishing and rust-removing.
- Aluminum oxide is backed with production paper, and it is used on wood and light-weight metal surfaces because aluminum oxide's tough coating cuts faster and longer than flints.
- Silicon carbide is produced by fusing silica and coke and it is a sharp abrasive. It is used on lacquers, plastics, composition materials, or metals for wet and dry sanding.

(1) Abrasives are fastened to paper, cloth, or fiber and are available in sheets, belts, or discs for use on sanders. The following are the weights and uses for paper- and cloth-backed abrasives:

(a) Paper-backed abrasive comes in four popular weights that are designated as A, C, D, and E:

- A is soft and flexible and is used where flexibility is desired.
- C and D are thicker and are used where flexibility is not necessary.
- E is heavier and is used mostly for machine sanding.

(b) Cloth-backed abrasive comes in two weights, J and X:

- J is used with emery for hand sanding.
- X is used mostly with power tools.

(2) In the past, manufacturers listed their abrasives by a complicated number system. A newer system labels the paper grades by terms such as fine, medium, and coarse. You will find both systems in use today. In the left column, of Table 3-1, page 3-8, is a list of the new label grades. The relating old number grades are found in the middle and right columns for garnet, aluminum-oxide, and flint. Use Table 3-2, page 3-8, to select the correct abrasive type and size when selecting abrasives based on a work surface or an intended use.

Table 3-1. Label and number grade comparisons

Label Grade	Number Grade for Garnet and Aluminum Oxide		Number Grade for Flint	
	Corresponding number	Grit number comparison	Corresponding number	Grit number comparison
Superfine	10/0	400	NA	NA
Extra fine	9/0	300	NA	NA
	8/0	280	NA	NA
	7/0	240	NA	NA
Very fine	6/0	220	4/0	150
	5/0	180	3/0	120
	4/0	150	2/0	100
Fine	3/0	120	NA	NA
	2/0	100	0	80
Medium	0	80	1/2	60
	1/2	60	1	50
Coarse	1	50	1 1/2	40
	1 1/2	40	2	36
Very coarse	2	36	2 1/2	30
	2 1/2	30	3	24
	3	24	NA	NA

Table 3-2. Selecting abrasives by work surface or intended use

Abrasive Type	Coarse Number Grade	Medium Number Grade	Fine Number Grade	Surface or Use
Aluminum oxide	2 1/2 to 1 1/2 1 1/2 1 1/2 to 1 3 to 2 1/2	1/2 to 0 1/2 to 0 2 1/2 to 0 1/2 to 0	3/0 to 2/0 2/0 3/0 to 2/0 2/0	Hardwood Aluminum Copper Steel and sheet metal
Garnet	2 1/2 to 1 1/2 1 1/2 to 1	1/2 to 0 0	3/0 to 2/0 2/0	Hardwood Softwood
Flint	*3 to 11/2*	*1 to 1/2*	*NA*	*Paint or rough scale removal*

(3) There are three powdered abrasives: pumice stone, rottenstone, and jeweler's rouge. Powdered abrasives are used primarily on furniture for fine-woodwork finishing, to smooth the finishes between coats of paint, and to polish metal surfaces. Pumice stone comes in grades F, FF, FFF, and FFFF. The best all-around powdered abrasive to use is FFF. Only one grade is available for rottenstone or jeweler's rouge.

h. Metallic Wools. Metallic wools have a variety of uses, and in many areas, they are better than abrasives. There are four major types of metallic wools: aluminum wool for use on aluminum; copper wool for use on copper; stainless-steel wool for use on stainless steel; and steel wool (the most common type) for use on steel, iron, and wood. Metallic wools come in six grades that number from 3 (coarsest) to 3/0 (finest). Use Table 3-3 as a guide for selecting the correct steel-wool grade.

Table 3-3. Selecting steel-wool grades

Label Grade	Number Grade	Use
Very Fine	3/0	Final smoothing
	2/0	Between paint coatings (with oil)
Fine	0	Common use
Medium	1	General-purpose work
	2	Rough work
Coarse	3	Restoration work

i. Blowtorches. Use blowtorches (Figure 3-10, page 3-10) to remove paint from interior and exterior surfaces. Blowtorches are available in many forms and use gasoline, alcohol, acetylene, or petroleum gas for fuel.

(1) To fill a blowtorch, turn it upside down and unscrew the filler plug. Pour unleaded gasoline (leaded gasoline will clog the torch) into the base, which serves as a funnel. When the tank becomes full, replace the filler plug and wipe off the excess gasoline. Turn the blowtorch upright, then operate the air pump to put pressure on the gasoline in the reservoir. Pour a small amount of gasoline in the bowl located below the vaporizing assembly, and ignite the gas. You can also place gasoline in the bowl by opening the needle valve by a small amount and allowing the gasoline to drip into it. When the gasoline in the bowl is almost burned, open the needle valve and the torch will light. In addition to conventional blowtorches, there are torches that use pressurized petroleum. These torches are very convenient, especially for removing paint from small areas.

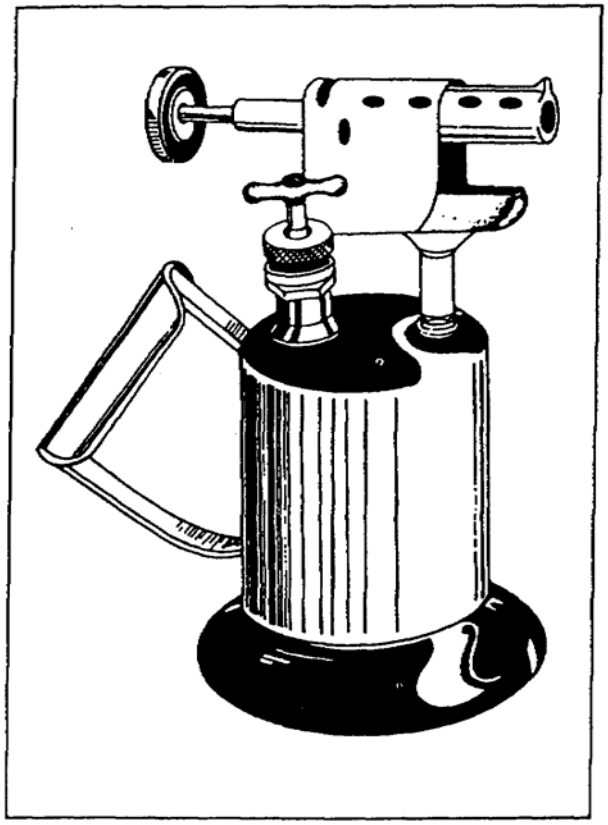

Figure 3-10. Blowtorch

(2) A blowtorch can be dangerous if it is not used correctly. The following safety rules apply to the use of a blowtorch:

- Never light a blowtorch in an unventilated room.
- Always set a blowtorch on a solid surface while lighting it.
- Never move a blowtorch while gasoline is burning in the bowl located below the vaporizing unit.
- Never light a blowtorch in the presence of wind.
- Never use a blowtorch near draperies or curtains.
- Never use a blowtorch near windows as its heat will crack the glass.
- Always go back over your work to ensure that no fire exists.

j. Heat Guns and Plates. Heat guns (Figure 3-11) work best on even surfaces, such as trim and molding. Heat plates make fast work of flat surfaces, such as siding. While

these tools generate enough heat to set wood or hidden debris afire, the risk posed is much less than using blowtorches.

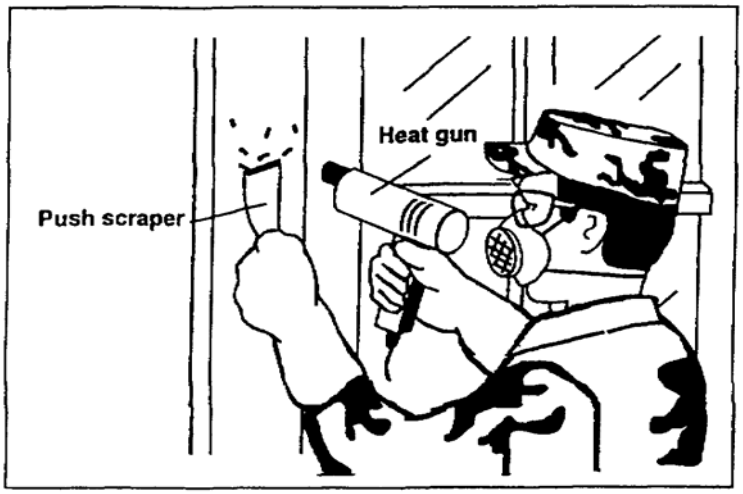

Figure 3-11. Heat gun

k. Caulking Guns. Caulking guns come in two different styles. One style is cartridge-loaded, and the other is loaded by unscrewing the gun end and filling the body with bulk compound. The guns are used to-

- Fill cracks between window frames or doorframes and the building's structural walls.
- Fill cracks in masonry surfaces before painting.
- Fill the crack between the baseboard, interior woodwork, or wallboard and before painting.
- Disperse asbestos or fibrous roofing cement onto shingles.

Ensure that the guns are cleaned after use because the unused caulking compound will harden and ruin the guns.

3-2. Power-Operated Tools. You can save much time and effort by using power-operated tools. Additionally, several operations can be performed by the same power unit by using different attachments. For example, one power unit can accommodate a grinder, a sander, or a buffer.

a. Power Wire Brushes. Use power wire brushes to conserve man-hours in large work areas. Use the brushes to remove paint from wood, masonry, or metal surfaces, and corrosion from metal surfaces. You should use brushes made of fine spring steel. Figure 3-12, page 3-12, shows two wire-brush types that are used on an electric or air motor, a flexible-shaft machine, or in the chuck of an electric drill. They can also be mounted on a

stationary or portable grinder. No maintenance is necessary; however, replace brushes when they wear down.

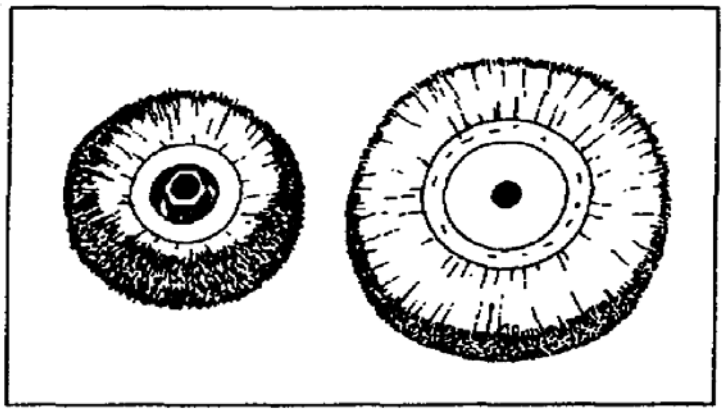

Figure 3-12. Power wire brushes

b. Power Sanders. Use power sanders to remove paint or corrosion from metal and wood surfaces and to smooth surfaces for finishing. There are many types of power sanders available, but the sanders you will use most are the portable vibrator; the belt, disc, and drum floor sander; and the floor edger. You must wear safety goggles or a face mask while using sanding machines. Start all portable sanders before placing them on the work area.

(1) Portable vibrator sander. A portable vibrator sander (electric) is a small machine with an abrasive sheet clamped on it. An orbital vibrator sander, shown in Figure 3-13, is small enough for you to hold in one hand while sanding. This tool is excellent for removing old paint and varnish and for sanding drywall joints. No maintenance is necessary on this machine.

(2) Portable belt sander. Use a portable belt sander (Figure 3-14) for finishing work and for fast and efficient sanding of wood surfaces. The sander uses an endless, abrasive-coated belt that runs over two flat pulleys. You will need to use both of your hands to operate the sander, and you must use extreme caution to ensure that the sander does not cut the wood surface too deeply. Occasionally clean the sander with compressed air.

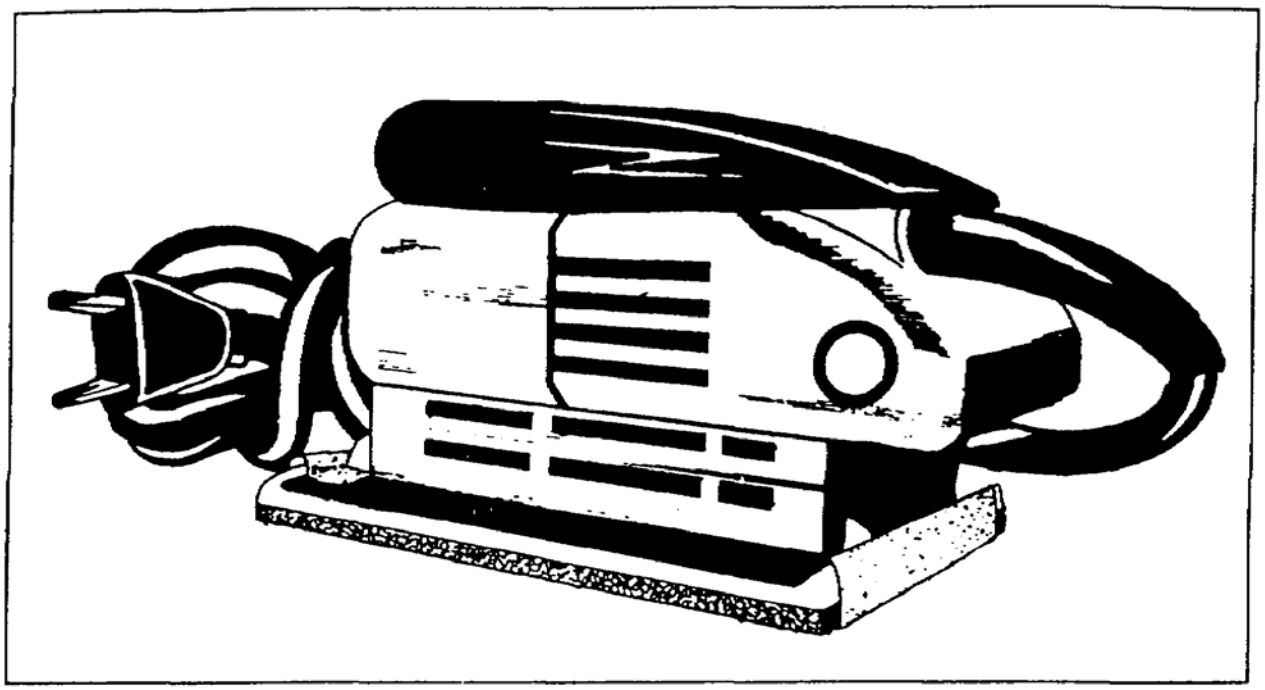

Figure 3-13. Orbital vibrator sander

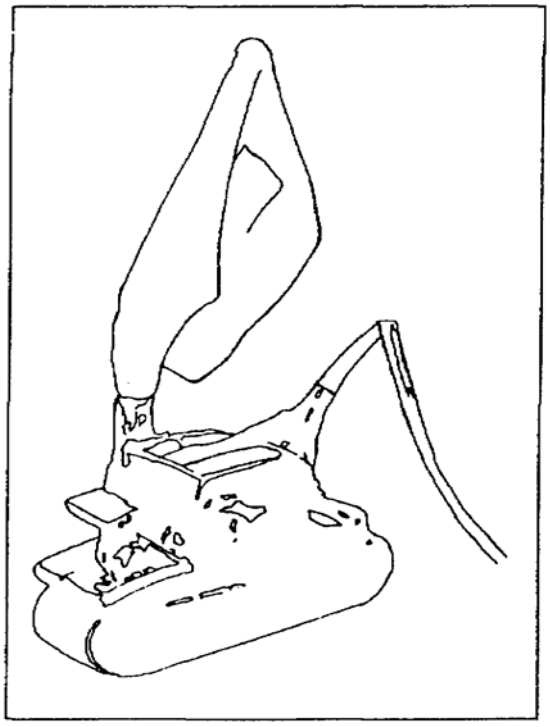

Figure 3-14. Portable belt sander (with dust bag)

(3) Portable disc sander. Use a portable disc sander (Figure 3-15) on metal surfaces or to remove badly flaked paint on wood surfaces. One type fits the chuck of an electric drill or a power tool. The sander's abrasive discs come in various grits for various tasks and are easily replaced.

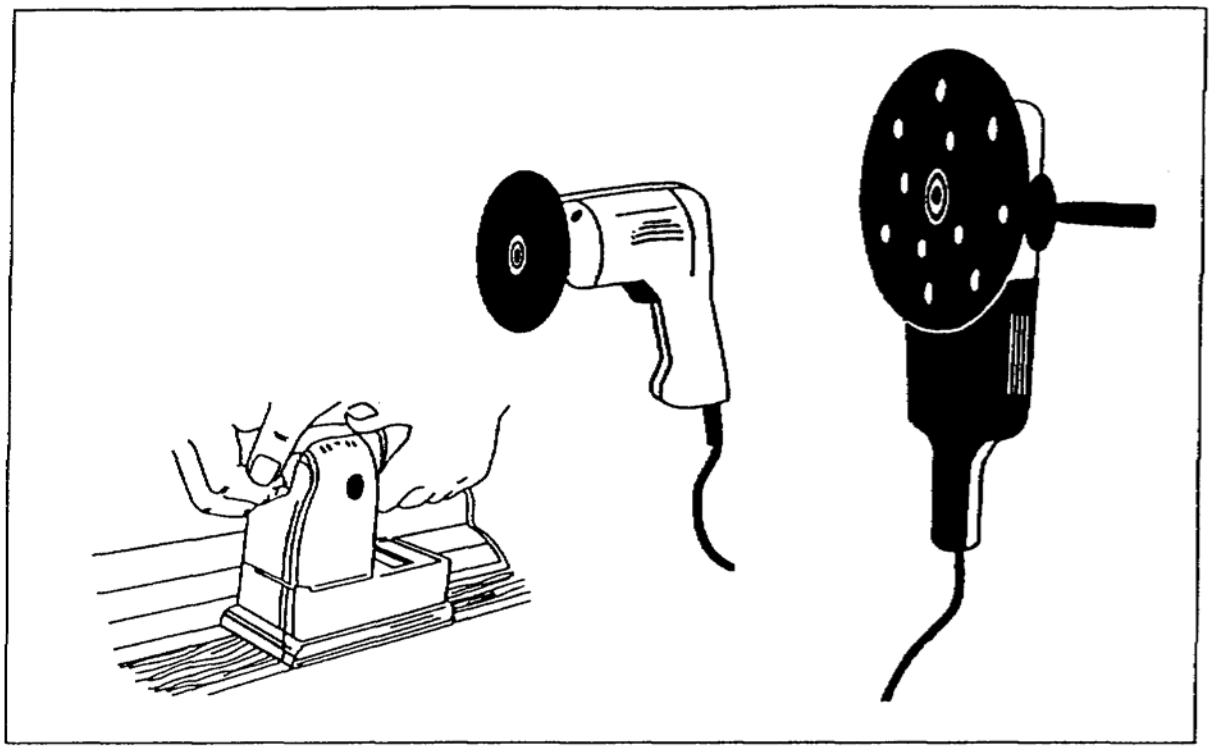

Figure 3-15. Portable disc sanders

(4) Drum floor sander. The drum floor sander (Figure 3-16) uses an abrasive belt that is similar to the belt sander. It is used to sand new or painted wood floors; however, because of its size, the drum floor sander cannot sand close to walls and in corners. The only maintenance required on this machine is to occasionally blow compressed air through the motor and replace the belt when it becomes worn.

(5) Floor edger. The floor edger (Figure 3-17) is very similar to the portable disc sander; in fact, their abrasive discs are interchangeable. The floor edger is designed to sand close to walls and in corners, thus eliminating much hand sanding. Clean the edger by blowing compressed air through the motor occasionally.

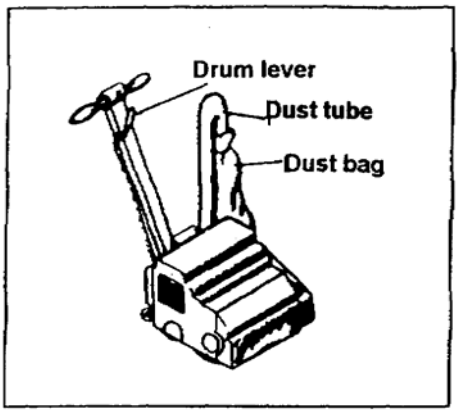

Figure 3-16. Drum floor sander

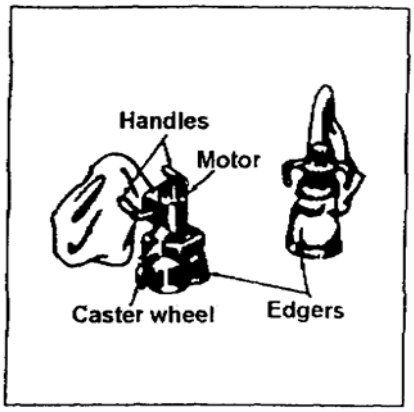

Figure 3-17. Floor edger

c. Power Buffers. There are two types of power buffers; one type is used to buff wood floors, and the other type is used to put a high polish on metal surfaces. Buffers are cleaned in the same manner as other power equipment by removing dust from the motor with compressed air.

(1) Floor buffer. A floor buffer weighs approximately 30 to 40 pounds. The polishing pads vary in size from 12 to 22 inches and are made of nylon, animal hair, or hog bristles. The pads can be obtained in coarse-, medium-, and fine-bristled materials.

(2) Metal buffer. A metal buffer is a rag wheel that is installed on a power tool or a bench grinder. It is also used with a flexible-shaft machine or in a portable drill that is equipped with a special chuck. The rag wheel is charged with a buffing compound (jeweler's rouge, rottenstone, or pumice). It is essential that you wear a face mask and gloves to protect you from fine particles that come from the rapidly turning, charged rag wheel. The fine particles are capable of cutting your flesh.

d. Portable Power Grinders. Use grinders to remove scale or encrustation from metal surfaces. The tool, as shown in Figure 3-18, page 3-16, is driven by an electric motor that uses 110-volt, 60-cycle alternating current. The electric motor in the grinder is geared and has a chuck. The features make it possible to attach different grit-sized abrasive wheels. The action of the grinder may be clockwise or counterclockwise. You must wear goggles when you are using a grinder, and your safety guard must be in place. You should use reinforced abrasive wheels and never exceed the operating speed indicated on the wheel blotter.

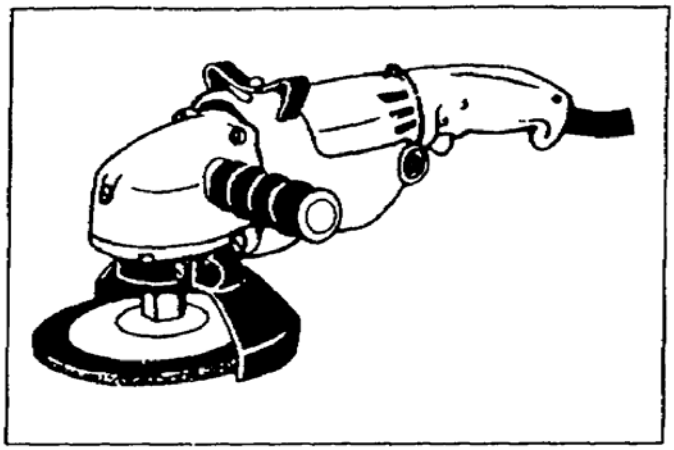

Figure 3-18. Portable power grinder

e. Descalers. Descalers are electric or pneumatic hammers with multiple-needle heads. The needles are interchangeable with a chisel-like unit. This tool is good for cleaning hard-to-get-at areas on metal surfaces, such as grooves, corners, crevices, rivets, protruding nuts or bolts, and gratings. The descaler operates with a reciprocating action and hammers the surface clean with wear-resistant alloy needles. This tool weighs approximately 4 1/2 pounds and is 14 to 20 inches long. When using this tool, you should wear goggles and a face shield or a hood.

f. Portable abrasive blasters.

(1) Use portable abrasive blasters (Figure 3-19) to remove paint from metal or masonry surfaces and corrosion from metal surfaces. Blasting is a very effective method of removing traffic markings from concrete paving.

(2) Abrasive-blasting equipment is simple to operate. In fact, only 8 to 16 hours of operating time is required to acquire a basic knowledge of abrasive-blasting techniques. However, simple though the operation may be, each equipment type has its own peculiarities. Because of this, you should closely follow the operating instructions of the specific equipment to prevent damage to the equipment or to the material being cleaned.

(3) The abrasive blaster is operated by compressed air. The air pressure bombards the surface with the abrasive (sand, grit, split shot, or glass beads) at a high velocity. If the compressed air is furnished by a portable compressor, you must follow the manual for operating this particular compressor type.

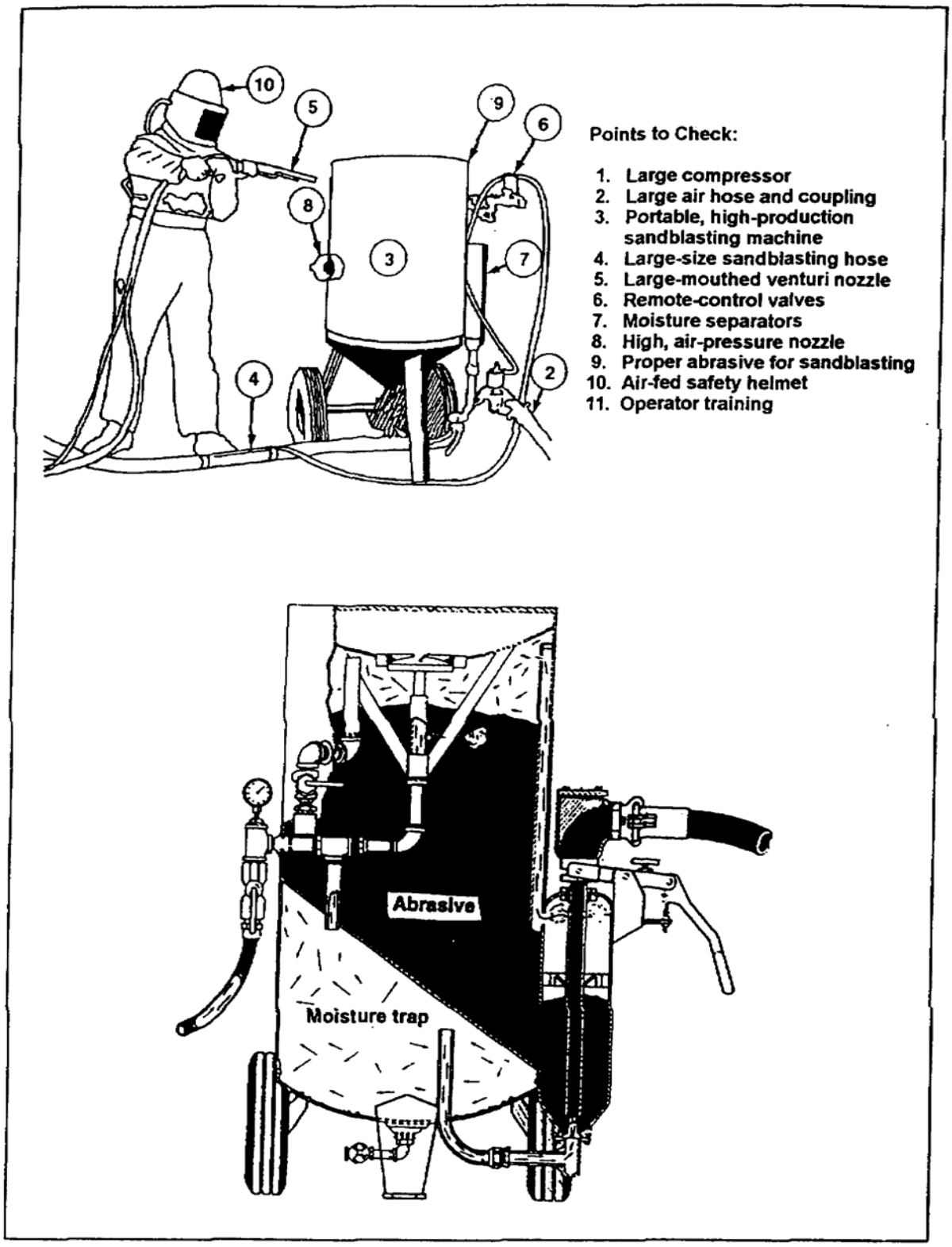

Figure 3-19. Portable abrasive blaster

(4) The following instructions are for a typical abrasive-blasting unit. You must check your operator's manual on your specific blaster, as each unit has its own peculiarities. You should-

- Inspect the hopper control to ensure that it is in the dosed position before you attempt to start the blaster. You must also check the sand blasting hose's electrical ground-wire attachment. This precaution is necessary because abrasive-cleaning produces static electricity, which is a fire hazard, particularly around dust areas.

- Wear complete head and face covering at all times. Also, you must ensure that you have been provided with pure, oil-free air for breathing when blasting in confined areas.

- Perform operator maintenance on the blaster as follows:

  - After 5 hours of operation: Disassemble the blast gun and inspect the nozzle for wear or cracks. Replace the nozzle when the inside diameter exceeds 3/8 inch or when it is cracked.

  - Daily: Remove and fill the chamber screen with abrasive material.

  - After 20 hours of operation: Depressurize the blast generator, place the choke relief valve in the abrasive-flow position, and remove the mixing valve. Disassemble the mixing valve and inspect the diaphragm, the valve-seating surfaces, and the passageways for abrasion or rigging. Replace worn parts, as necessary, and reassemble/reinstall the mixing valve. Remove the cover on the swing check valves (two each), and ensure that the valves' flappers seat and operate freely.

- Discharge the leftover abrasive through the gun if the abrasive-blasting unit will not be in use for sometime. To remove the small quantity that is below the level of the pump inlet, open the drain valve at the bottom of the hopper.

g. Portable vacuum blasters. Use portable vacuum blasters for the same purposes as abrasive blasters. One big advantage of the vacuum blaster is that the used abrasive, debris, and dust are removed by the vacuum during the blasting process.

h. Steam cleaners. A steam cleaner (Figure 3-20) consists of a metal cabinet that houses such components as an electric motor or gasoline engine and units for individual water, soap, and heating systems. A steam cleaner blends the detergent with water and pumps the solution into a heating unit, where it is partially vaporized. The heat, plus vaporization, generates pressure in the system. The solution is then directed to the cleaning hose and gun from which it is sprayed upon the surface to be cleaned. The detergent and spray, together with impact (friction) caused by high velocity, loosen and remove the dirt and encrustations. After you have completed the cleaning operation, the vaporized spray can be converted into a solid, high-velocity stream of water for rinsing the material you are cleaning.

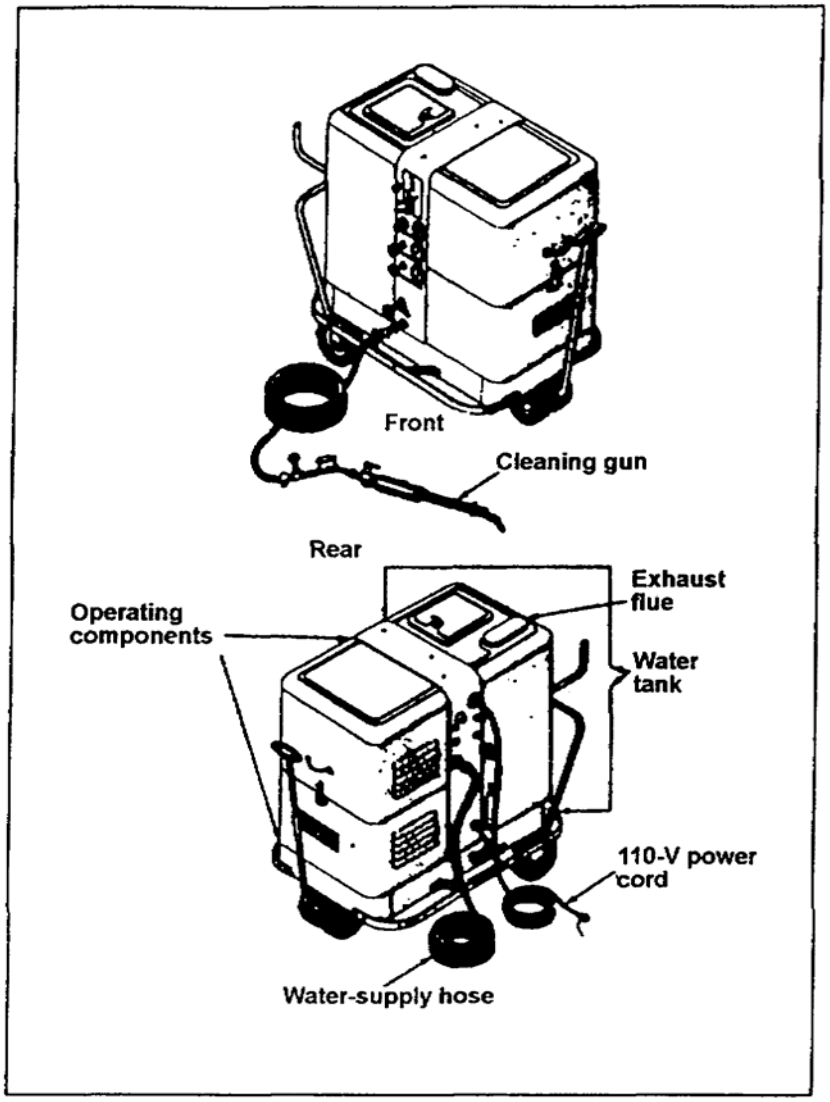

Figure 3-20. Steam cleaner

i. Vacuum cleaners. Before applying protective coatings, use industrial or domestic vacuum cleaning equipment to remove items such as dirt; dust; small, loose objects; and paper from surfaces and areas. To loosen the soil caked on the vacuum cleaner's inlet, use a soft-bristled brush.

Always remember to check the applicable TO or operator's manual when you are using any of the equipment or items discussed above or when performing maintenance.

PART B: APPLICATION EQUIPMENT

Your job is to apply protective coatings to buildings and other structures. It is necessary that you know how to select the best methods and equipment to do a satisfactory job faster, safer, and the most economical for the military. To avoid duplication, equipment that is used for surface preparation and application is covered in only one of the categories.

3-3. Paint-Preparation Tools. The basic tools to assist with protective-coating preparations and applications are hand paddles, power mixers and shakers, paint buckets, and paint strainers.

a. Hand Paddles. Use hand paddles to keep paint well-mixed while you are painting. Using wood-hand paddles allows you to discard them after their use and saves a cleaning job. More efficient metal hand paddles with holes in the blade are also available. However, if a power mixer is available, it is not economical to mix large paint quantities with a hand paddle.

b. Power Mixers and Shakers. These tools were covered in Lesson 2.

c. Paint Buckets. Several plastic buckets that hold at least 1 1/2 gallons are very useful for mixing paints and for cleaning brushes after their use. A paint-can extender (splash guard) is also handy when you are stirring paints in the original paint container.

d. Paint Strainers. Strain paint that has set all night and strain mixtures of dry pigments and oils before use. Also strain any coating that is used in a spray gun. Some strainers are made of paper or cloth, and they are inexpensive and disposable; however, always dispose of used strainers in a fireproof container. Other strainers are made of fine wire mesh; they are cleaned with the same material used to thin the paint mixture.

e. Paint Guide. Use a paint guide (Figure 3-21) to help with painting in tight corners and to keep paint off ceilings and trim. Be careful not to get paint on the back of the paint guide.

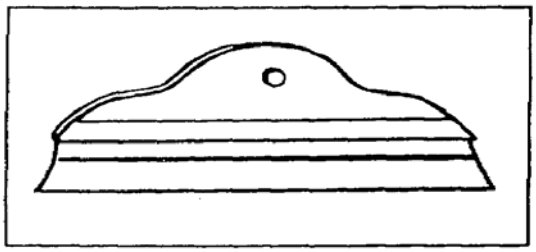

Figure 3-21. Paint guide

3-4. Paintbrushes. It is important for you to select good-quality paintbrushes of the correct size and shape for a particular job. You must also know how to care for paintbrushes, store them properly, and reclaim abused paintbrushes.

a. Selection. Besides choosing good-quality paintbrushes, you should also select brushes that are the right size and shape for the job. For example, using a small paintbrush on large surfaces not only wastes energy but also prevents proper paint spreading. Applying paint to a smooth surface requires good-quality paintbrushes. They are well-bristled, and the bristles are springy. The bristles of good-quality paintbrushes are flagged at the ends to hold and help spread paint; where as, poor-quality paintbrushes will neither hold paint well or spread it evenly. Figure 3-22 shows the principal paintbrush parts. Good-quality bristles are made from natural or synthetic bristles or a mixture of these materials (Figure 3-23).

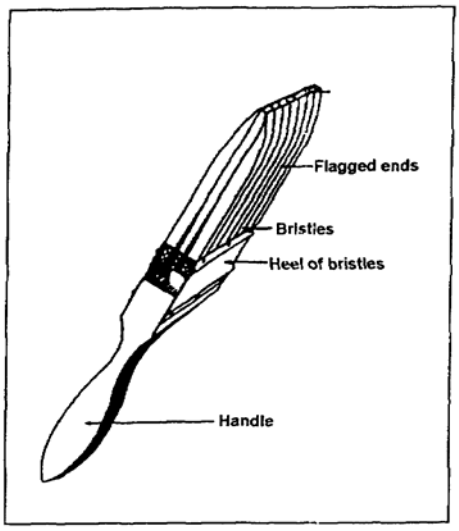

Figure 3-22. Principal paintbrush parts

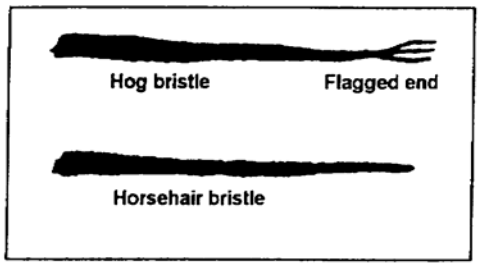

Figure 3-23. Bristles

b. Materials, Sizes, and Shapes.

(1) Common materials for paintbrushes are hog bristle, nylon, and horsehair

- Hog bristle is suitable for applying enamels or oil-based paints that produce a smooth finish on interior or exterior surfaces. The hog bristle is a tapering, hollow tube that forms natural, flagged ends. The flagged end of each bristle is like a little brush. These ends pick up and carry large amounts of paint and help spread the paint evenly on the surface. Hog bristles wear away and continuously form flagged ends as the tube splits.

- Nylon is suitable for applying water- or oil-based paints to interior or exterior surfaces. This synthetic bristle is tapered and possesses the resiliency and toughness required for painting operations. Nylon bristle is similar to hog bristle, except the ends of nylon bristle are sanded to make them flag. After they are once flagged, they will continue to flag naturally as the bristle wears away. Do not use nylon bristles to apply lacquer, since the solvents will ruin the bristles. Cleaners containing strong acid, alcohol, or phenolic solutions will damage synthetic bristles.

- Horsehair is a substitute for hog bristle. It is made from a horse's mane and/or tail, and it does not have the elasticity and life found in hog bristle. Horsehair does not retain its stiffness when immersed in oil or paint. It lacks toughness, strength, and wearing qualities; and it paints unsatisfactorily.

(2) Paintbrushes are available in various sizes and shapes. They are used for the following special purposes:

- Large surfaces. Use paintbrushes that measure from 3 to 6 inches wide to apply paint or stain to large wall surfaces (interior or exterior). Flat wall paintbrushes (Figure 3-24) are 3/4 to 1 1/2 inches thick and have bristles from 2 to 7 inches long. Large-surface paintbrushes are usually square-ended and square-edged, with the natural bend of the bristles bending toward the center.

- Sash and trim surfaces. Sash and trim paintbrushes (Figure 3-25) vary in shape and size, but most are 1 to 3 inches wide. To get close to windowpanes, one paintbrush has bristles that are beveled like a cold chisel. An angular-cut sash paintbrush is used by some painters when painting hard-to-reach spots. Another type preferred by some painters is almost oval in shape.

- Clear coatings. Use a paintbrush designed for a varnish (Figure 3-26), shellac, or lacquer finish. The brush is usually chisel-shaped, which contributes to smoother applications and prevents lap marks. Paintbrushes are 2 to 4 inches wide and have extra-fine bristles that are 4 to 6 inches long.

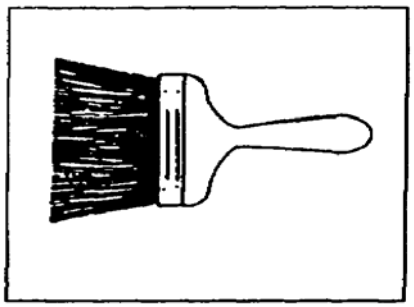

Figure 3-24. Flat wall paintbrush

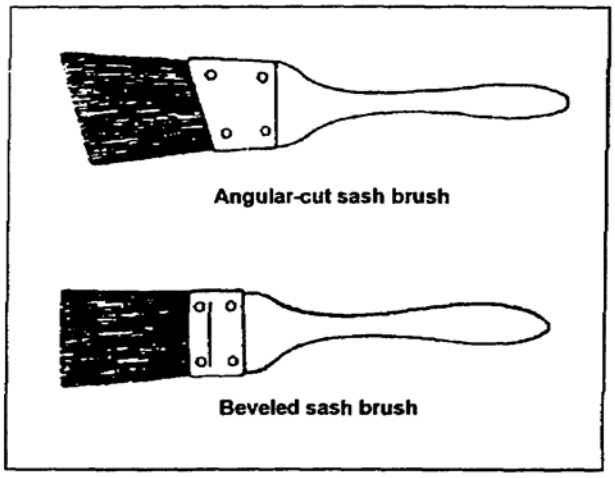

Figure 3-25. Sash and trim paintbrushes

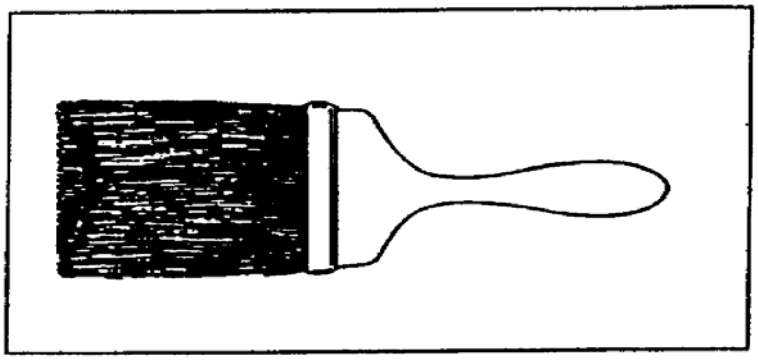

Figure 3-26. Chisel-shaped varnish paintbrush

3-5. Paintbrush Care, Cleaning, Storage, and Reclamation. A paintbrush's life span and usefulness diminishes with improper care, cleaning, and storage. The following will help you prevent or solve problems with paintbrushes:

a. Care.

- All paintbrushes contain a few short bristles that are not caught in the brushes' ferrule. Before you use a paintbrush, remove the short bristles by striking the bristles against the spread fingers of your hand. Before you start to paint, dip the paintbrush in paint thinner then shake the thinner out; thinner keeps the paint from hardening on the surface of the bristles and makes cleaning easier.

- Never stand paintbrushes, wet or dry, on their bristles. The bristles will set in a curve, and no amount of effort will restore them to their original condition.

- Never rub bristles over the edge of a container to remove excess materials, as this procedure tends to wear or break the bristles. Instead, tap the brush lightly against the inside of the container above the paint level.

b. Cleaning. Once material has hardened in a brush, it is extremely difficult to restore the paintbrush to its original pliability, so you should clean paintbrushes immediately after their use. The best paintbrush cleaners are the solvents used to thin coating materials. To clean a paintbrush that was used in oil-based paint, you will need rubber gloves, eye protection (safety glasses or goggles), cotton rags, a wire brush, at least a gallon of paint thinner, and a paintbrush spinner (optional)(Figure 3-27, page 3-24).

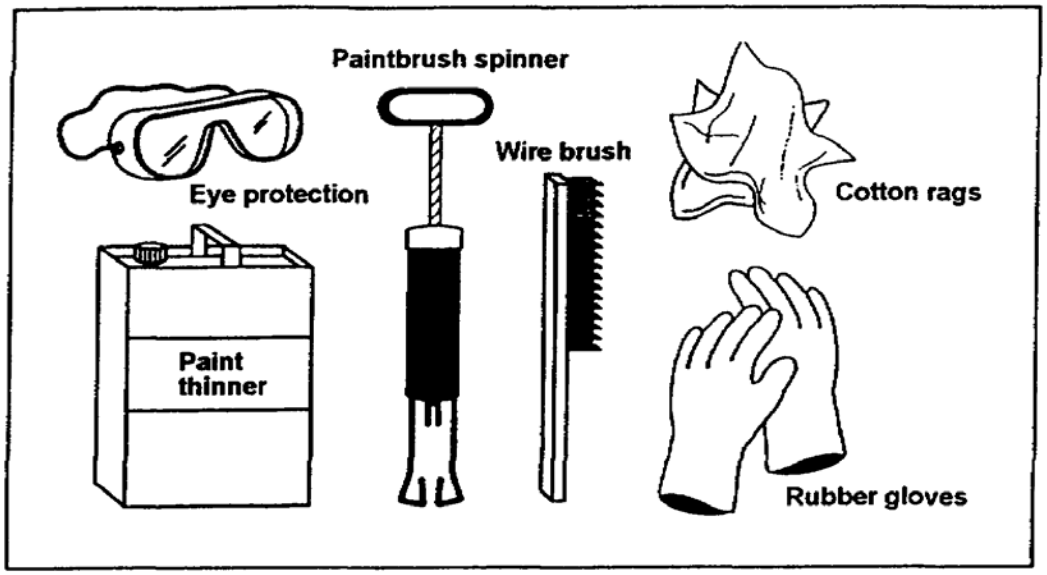

Figure 3-27. Oil-based paint cleaning materials

(1) Wear rubber gloves to protect your hands from chemicals. Use a rag to wipe off as much paint as you can from the paintbrush's ferrule (Figure 3-28).

(2) Proceed with the directions at paragraph 3-5b(3) below if you poured the paint directly into paint trays. Pour several inches of thinner into a used paint bucket. If you did not pour the paint directly into the paint trays, then wipe any paint off the bucket sides and bottom (Figure 3-29) with the paintbrush that you used for the paint job. This not only cleans the bucket, but it also begins the paintbrush-cleaning process. When the bucket is clean, pour the used thinner into any paint trays that you plan to clean, and pour fresh thinner into the clean bucket.

(3) Pour fresh thinner into a clean paint bucket, and soak the paintbrush in the fresh thinner for a few minutes. Then use a wire brush to "comb" (Figure 3-30) the flat sides and edges of the paintbrush from the ferrule toward the end of the bristles, forcing out the paint. Repeat this process for paint that is trapped inside the bristles near the
ferrule.

(4) Hold the paintbrush upside down, and bend the bristles back and forth, forcing thinner into the brush's heel (Figure 3-31). Repeat this several times while pouring clean thinner into the bristles. Continue until clear thinner runs out of the paintbrush.

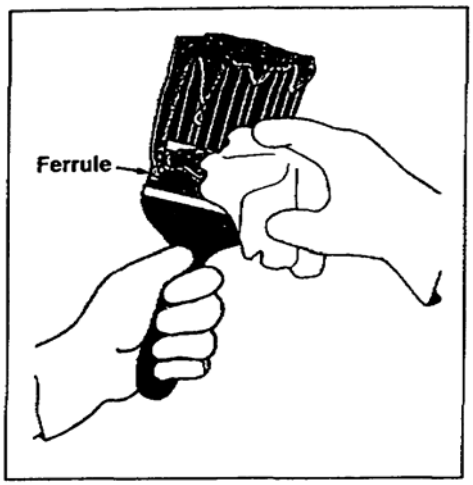

Figure 3-28. Removing paint off the furrule with a rag

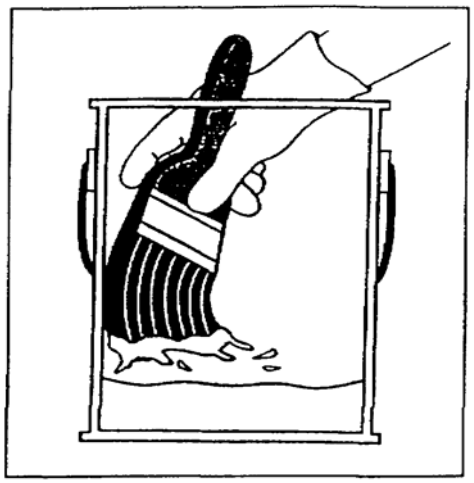

Figure 3-29. Cleaning the bucket sides with a paintbrush

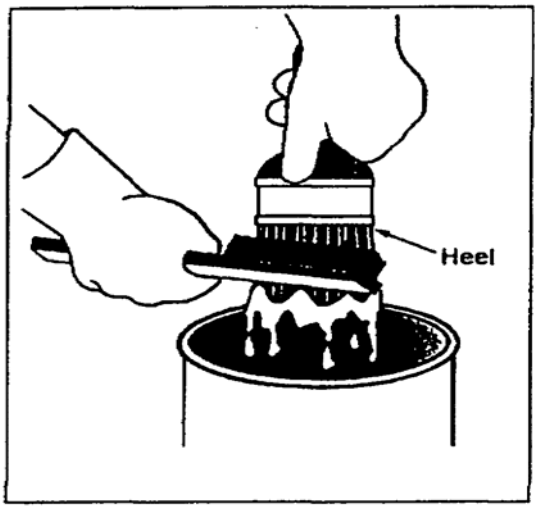

Figure 3-30. Using wire brush to get paint out of the brushes heel

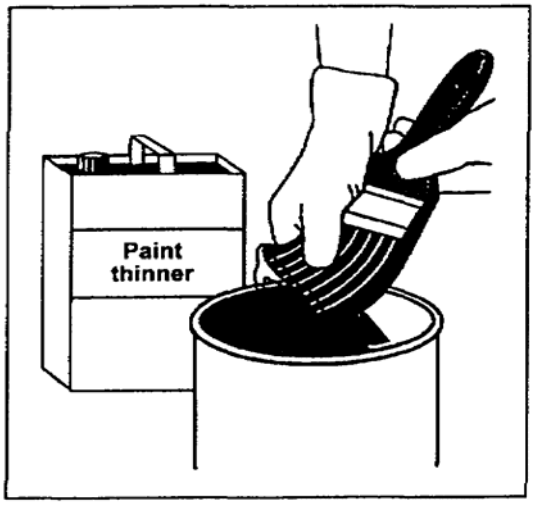

Figure 3-31. Using your hands to squeeze the bristles and force cleaner into the heel

(5) Use a spinner, if available, to get the last dregs of paint and thinner out of the brush. To do this, place the brush handle into the tangs of the spinner (Figure 3-32, page 3-26). Hold the spinner in the paint bucket or a trash can and pump the spinner until the brush is dry. If you do not have a spinner, spin the brush with your hands inside the paint bucket or a trash can.

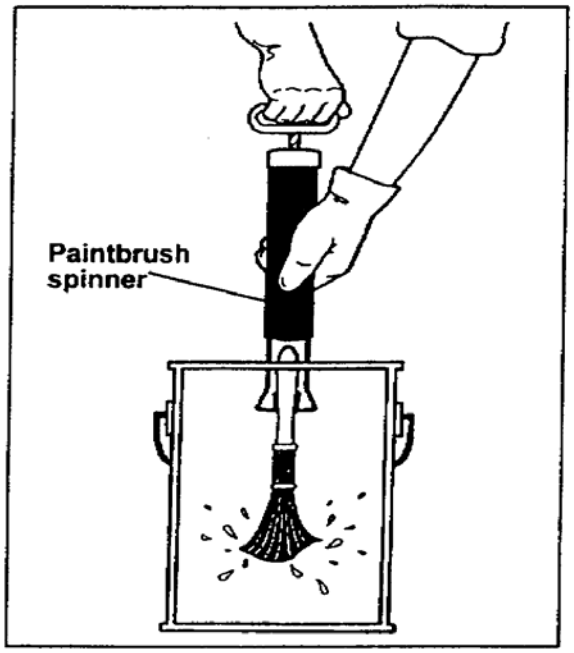

Figure 3-32. Spinning the paintbrush

NOTE: Do not pour oil-based paints or thinners down the drain. Thinners and solvents in paints are hazardous materials, and dumping them down a drain ensures that they will end up in the water supply. Check your local regulations for handling hazardous materials.

c. Storage. How you store your paintbrushes depends on their future use. Use the following procedures when storing paintbrushes for long periods or overnight:

(1) Long periods. When paintbrushes are not to be used for a length of time, clean the bristles with a wire comb then reshape the bristles. When the bristles are straight and parallel, wrap the cleaned paintbrush (Figure 3-33) in its original wrapper or butcher paper. Wrapping keeps the bristles from losing their shape as the paintbrush dries. Store paintbrushes flat, with no weight on the bristles.

(2) Overnight. Paintbrushes that are used daily should be kept overnight in a paintbrush keeper (Figure 3-34). Immersing cleaned paintbrush bristles in the proper oil solvent ensures that the bristles will remain soft and pliable. For paintbrushes used in oil-based paint or varnish, use linseed oil in the keeper; for paintbrushes used in lacquer, use lacquer thinner; and for paintbrushes used in shellac, use alcohol. Use enough solvent material to cover the bristles of paintbrushes in the keeper, and remember that brushes in the keeper should not touch the bottom of the keeper or each other.

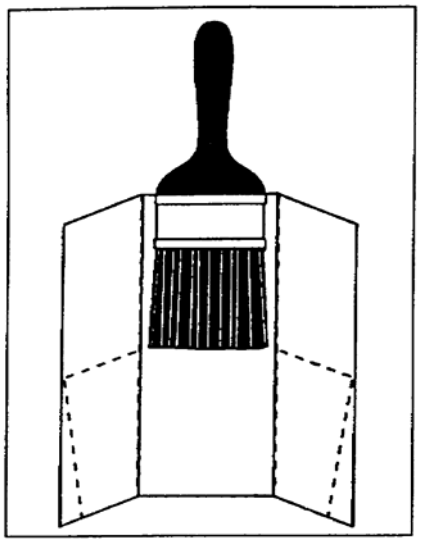

Figure 3-33. Wrapping a paintbrush for long storage

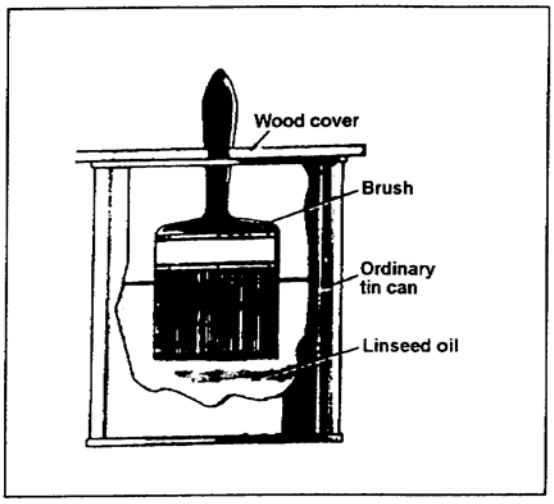

Figure 3-34. Placing a paintbrush in a paintbrush keeper for overnight storage

d. Reclamation. To reclaim a paint-hardened paintbrush, soak it in a commercial cleaner or a paint remover. A mixture of equal quantities of alcohol, acetone, and benzol is also used to soften a paint-hardened paintbrush (other than nylon). Leave the paintbrush in the solution until the bristles are soft and pliable. If the bristles are badly bent, soak the paintbrush in machine oil and lay the paintbrush on a heated piece of metal until the oil in the bristles sizzles. While the paintbrush is still hot, reshape and bind the bristles with metal wire strips. After the paintbrush has cooled, wash it in mineral spirits and rinse it with benzol or acetone. Wrap the paintbrush in paper to complete the process.

3-6. Paint Rollers. A paint roller consists of a cylindrical sleeve or cover which slips on to a rotatable cage that is attached to a handle. The most common roller types and sizes are shown in Figure 3-35, page 3-28.

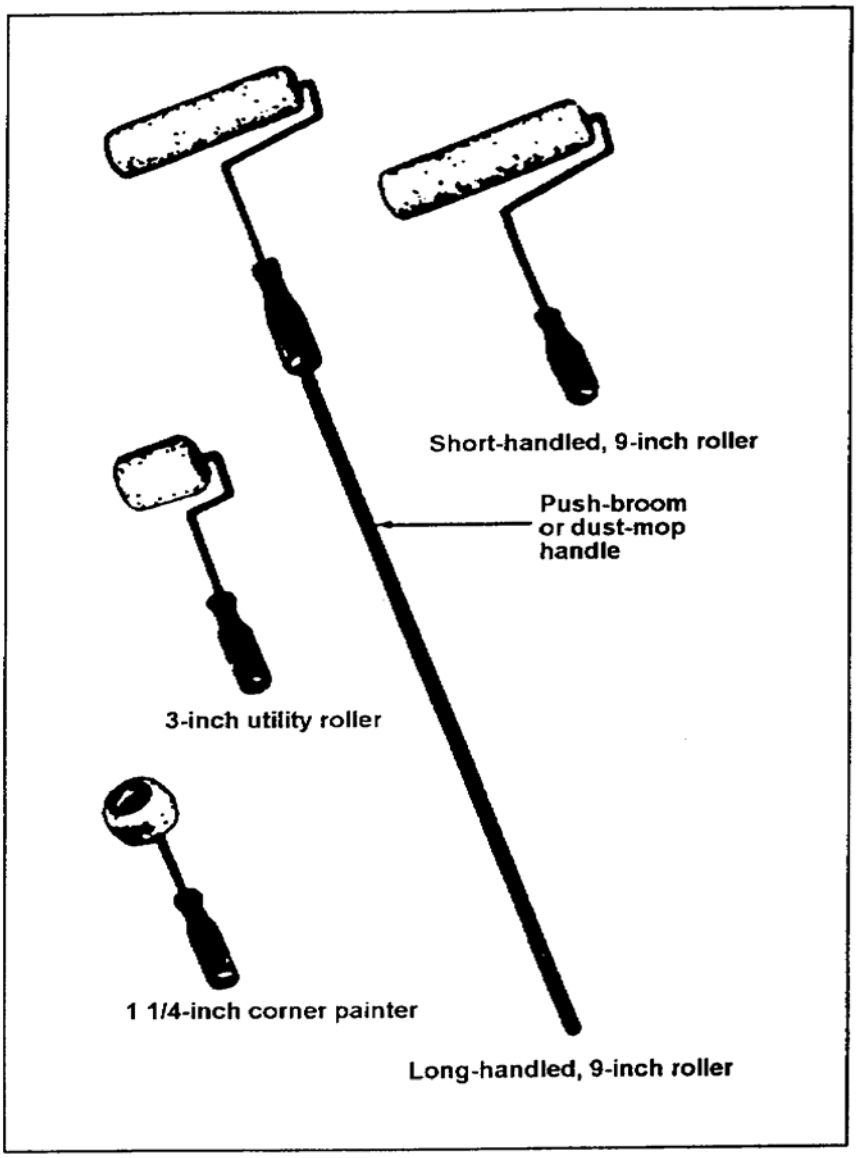

Figure 3-35. Paint rollers

a. Cover Materials. The most commonly used cover materials are lamb's wool, mohair, stippler, and high pile:

- Lamb's wool is used for general-purpose painting.
- Mohair is especially effective with enamels and rubber-based paints.
- Stippler is coarse-textured material that is used to produce a deep stippled finish.
- High pile is sometimes referred to as a long-nap cover. It is designed for painting rough surfaces such as brick, stucco, concrete, concrete blocks, tile, siding, shingles, fences, and other uneven surfaces.

b. Cover Care. Most rollers are constructed with covers that can be removed from the holder for cleaning. The cleaning materials for covers are determined by the type of paints used. For water-based paint, use soap and warm water; for enamel, use mineral spirits or turpentine followed by soap and warm water; and for shellac, use denatured alcohol, followed by soap and warm water. Dry the roller cover thoroughly before storing. When the cover becomes worn or unusable, replace it with a new one.

c. Sizes. The size roller you use will depend on where you are painting. Common sizes of rollers are small and industrial:

- Small rollers are 1 1/4 to 3 inches wide and are used to apply paint next to windows, door openings, and at corners where it is difficult to use larger rollers.

- Industrial rollers are available in widths up to 18 inches. The handles of industrial rollers are designed to accommodate a push-broom or dust-mop handle so that floors can be painted without kneeling and ceilings and high places can be reached without the use of scaffolds.

d. Paint Roller Trays. A roller tray (Figure 3-36) is usually a shallow, rectangular container made of metal. The tray is used to apply paint to the roller, and the tray size is determined by the roller's width. To control the amount of paint that stays on the roller, pull the roller over the ridges in the bottom of the tray. Clean the roller first, then clean the tray with the same materials you used to clean the roller.

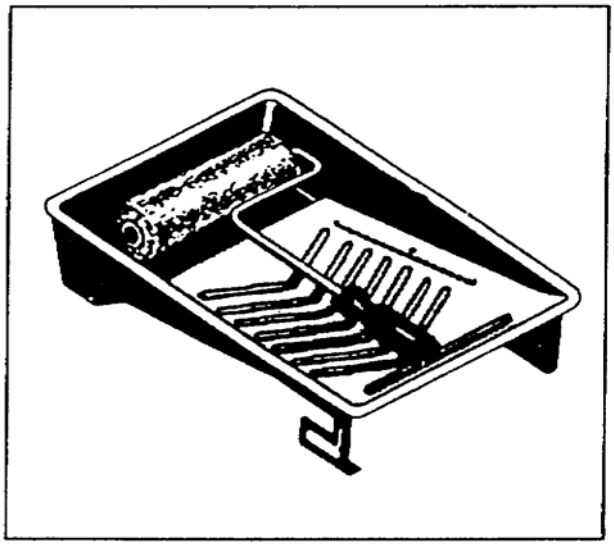

Figure 3-36. Paint roller and tray

3-7. Paint Spray Guns. There are many paint spray gun variations: the internal or external mixing, the suction or pressure fed, the bleeder or nonbleeder, and the attached or separate container. Each spray gun may be a combination of any of the variations listed.

a. Internal Mixing. This spray gun mixes paint and air inside the gun and spray cap. It is shown on the left side of Figure 3-37. The cap requires less air pressure than the external-mixing spray gun. The cap is popular on small spray guns. The main fault of the internal mixing feature is the tendency for fast-drying materials, which are atomized inside the cap, to collect inside and around the outlet. Pressure fed-spray guns are usually of the internal mixing type.

b. External Mixing. This spray gun mixes the paint and air outside the gun and spray can. It is shown on the right side of Figure 3-37.

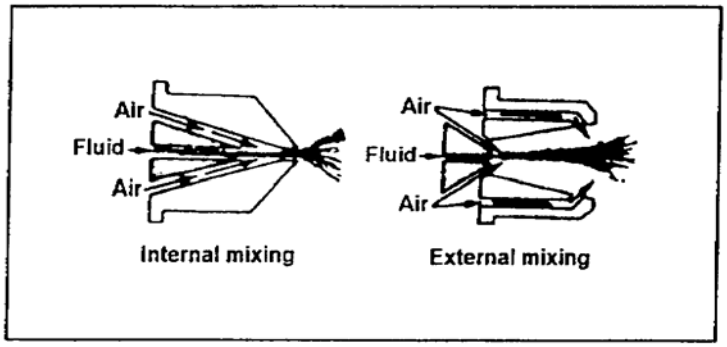

Figure 3-37. Nozzles of internal- and external-mixing spray guns

c. Bleeder. This spray gun is constructed in such a way that air passes through it at all times. This feature prevents excessive pressure buildups in the compressor. Use this type if the spray gun is to be connected directly to a small compressor.

d. Nonbleeder. This spray gun is used in conjunction with a compressor that automatically shuts off when pressure reaches the desired setting. When the trigger on the gun is released, air passing through the gun is stopped.

e. Suction Fed. This spray gun is one in which pressurized air passes over the tip of a fluid tube, sucks the fluid from the tube, and sprays the fluid into the airstream. This spray gun is identified by the presence of an air vent in the paint-cup cover. This spray gun is ideal for spraying small areas with lacquer, varnish, or other light materials. However, avoid using this gun when spraying heavy paints, since it will not pull heavy materials up to the nozzle.

f. Pressure Fed. This spray gun is made with an airtight container. The pressurized air directed into the container places the fluid under pressure, force the fluid up the fluid tube, and sprays the fluid. This spray gun will spray heavy paints or materials when supplied with a low air volume. It is considered one of the best general-purpose guns for use with regular paints. Pressure fed and suction fed spray-guns are the same, and both types can use internal or external mixing of fluid and air. Since no siphoning effect is necessary for pressure application, it is the best tool for volume painting.

g. Attached Container. This spray gun (Figure 3-38) is usually referred to as a cup type since the paint is held in a cup that is attached to the bottom of the gun. Cup-type spray guns, which require only an air hose, are used extensively in military painting.

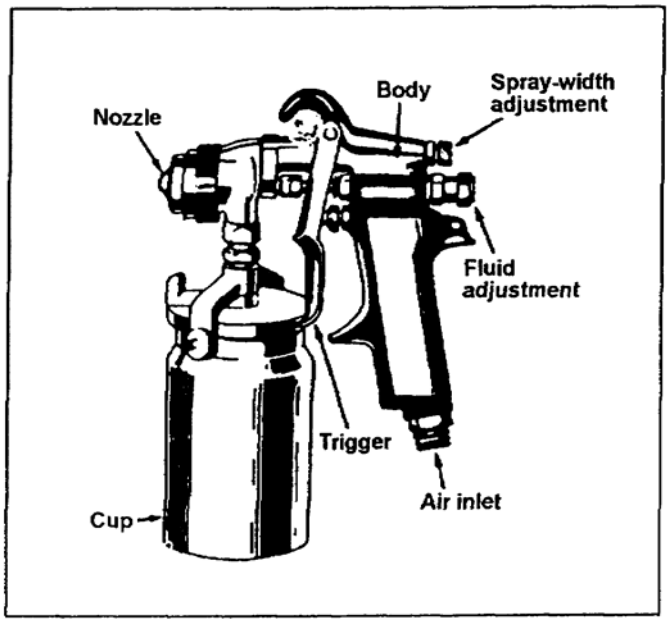

Figure 3-38. Attached-container spray gun

h. Separate Container. This spray gun (Figure 3-39) does not have a paint container or cup attached to the lower portion of the gun. The gun receives paint materials through a fluid hose, which is connected to a separate container called a material pressure-fed paint tank.

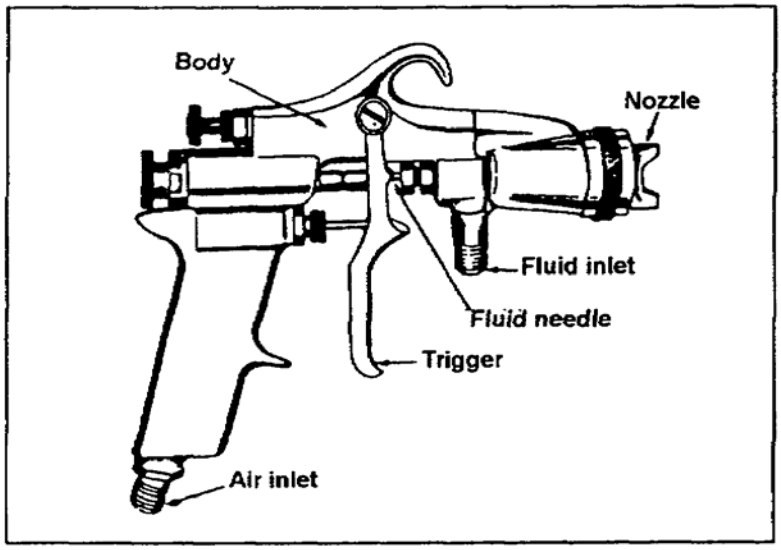

Figure 3-39. Separate-container spray gun

i. Pressure-Fed Paint Tank.

(1) A pressure-fed paint tank (Figure 3-40) is a large metal container that provides paint material at a constant flow and at uniform pressure to the spray gun. The spray gun is connected to the tank with two hoses, one for air and the other for paint material. The tanks range in size from a 2 to 60 gallons. The basic tank consists of a container with a clamp-on lid, an air-pressure regulator, and connections for fluid and air.

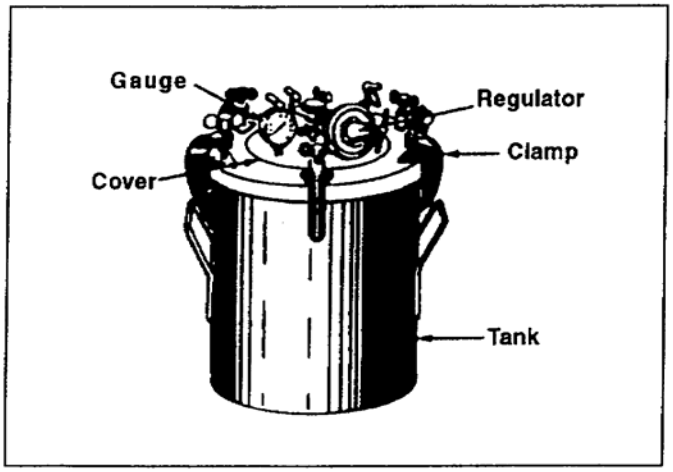

Figure 3-40. Pressure-fed paint tank

(2) In actual operation, air pressure from a compressor or some other air supply is forced into the paint tank. This air pressure causes the paint to flow out of the tank, through a fluid hose, to the spray gun. When the paint reaches the gun head, it comes in contact with air that is passing through the spray gun, then the paint is atomized and sprayed.

3-8. Spray-Gun and Paint-Tank Cleaning. Thoroughly clean the paint spray gun and the paint tank after each use. Remove the gun cap, wash and wipe out the tank or the spray-gun cap. Pour a small amount of solvent or thinner into the tank or cup, reassemble and apply air pressure until the solvent or thinner has been blown through the hose and gun. Finish by wiping off the units with a cloth that is moistened with solvent or thinner.

When air or paint passages become clogged with paint, it is necessary to dissemble the units and soak all metal parts in thinner or a paint-remover solution. After the solution has softened the paint in the air or paint passages, take an appropriate-sized soft wire and work it back and forth through the passages until they are open and clean.

NOTE: Do not use lye or any other caustic-alkali solution to clean paint-spraying equipment.

3-9. Spray-Gun and Paint-Tank Storage. Coat the surfaces of moving parts with a thin oil film whenever a gun or tank is stored for an indefinite time. Lubricate the spray

gun air valve daily with light oil. Keep all spray-gun packings, such as the fluid needle packing, soft and pliant by occasional applying oil.

3-10. Hoses. There are two types of hoses-air and fluid:

a. Air. Air hoses are generally lightweight, flexible, kink-free, and will withstand pressures as recommended by the manufacturer. For proper spray-gun equipment operation, the gun must receive an adequate supply of compressed air. Ensure that the required amount of air is applied by using air hoses of the proper size.

b. Fluid. Fluid hoses are usually made of synthetic rubber and are used with all types of painting materials, solvents, and oils. Fluid hoses are cleaned at the same time as the gun when thinner or solvent is forced through them by air pressure.

3-11. Air Compressors.

a. Air compressors are mechanical units designed to continuously supply compressed air at a specific pressure and volume. Compressors have an electric motor or a gasoline engine. The Army painter is primarily concerned with two types of air compressors-low pressure and high pressure.

(1) Low Pressure. The low-pressure air compressor shown in Figure 3-41, weighs approximately 50 pounds. The overall weight of this unit includes the air-pressure pump, the air-pressure tank, and the driving unit. Since the spray unit is designed to operate on pressures from 20 to 40 pounds per square inch, you should exercise caution against applying higher pressures. Because this gun operates at low pressures, it is not recommended for spraying quick-drying paints, lacquers, or enamels.

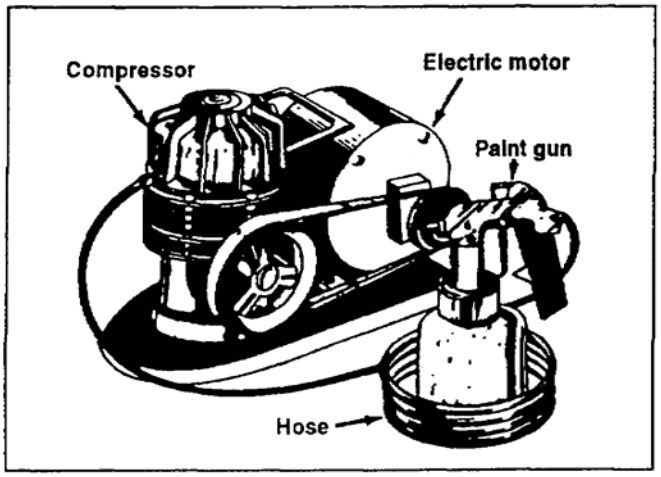

Figure 3-41. Low-pressure air compressor (electric motor)

(2) High Pressure. Use this compressor for large jobs where heavy-duty spray equipment is required. A high-pressure air compressor is shown in Figure 3-42, page 3-34.

Cleaning the air filters and servicing the crankcase are the only maintenance services needed on an air compressor. Some compressors may require additional lubrication in the oil cups, grease cups, or grease-gun fittings. If electricity is available, electric motors are more satisfactory than gasoline engines for driving compressors because electric motors require very little maintenance.

b. Where electric power is not available, a gasoline engine-driven unit must be used. The preventive maintenance services for a gasoline engine are similar to those for any gasoline engine. The lubricating oil in the crankcase must be kept at the proper level. If it is low, add enough oil to bring the level up to the full mark. In addition, the oil in the crankcase must be changed; and if the engine has an oil filter, the filter cartridge is changed when the oil is renewed. You should also clean the air filter as recommended by the manufacturer. Be sure to check the manufacturer's handbook or the applicable TO for operating instructions and maintenance of the particular type of equipment that you have.

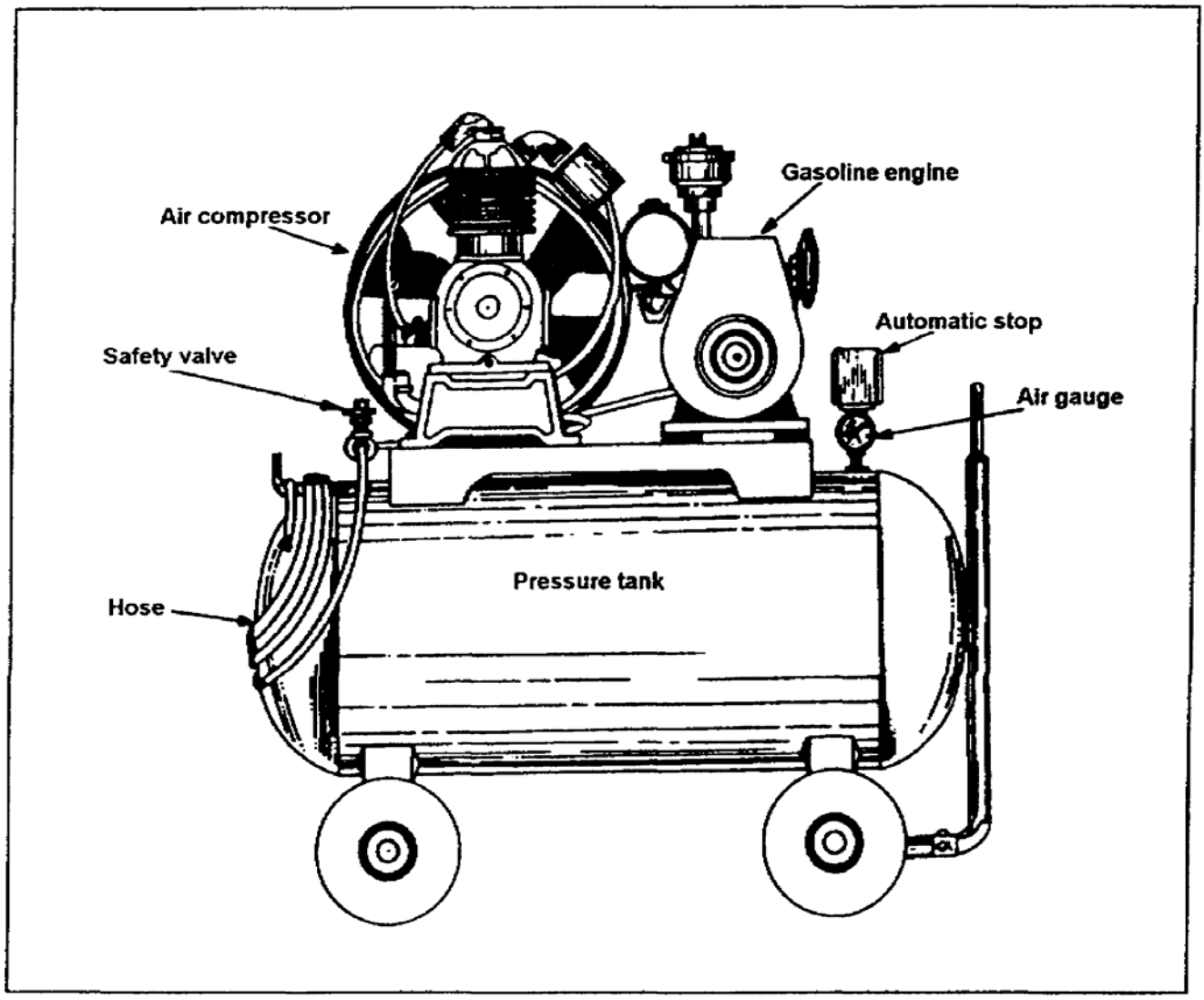

Figure 3-42. High-pressure air compressor (gasoline engine)

3-12. Airless Spray Systems.

a. In an airless spray system (Figure 3-43), the spray is created by forcing paint through a restricted orifice at very high pressure. Paint atomization occurs without the use of air jets, thus the name airless spray. Liquid pressures from 1,900 to 2,600 pounds per square inch are developed in special air-operated, high-pressure pumps and delivered to the gun through a single hose line.

b. The system provides a very rapid means of covering large surfaces with a wide-angle spray without producing overspray mist or rebound. The single, small-diameter hose makes gun handling easy. The spray produced has a full wet pattern for quick film buildup. However, the system requires extra care when lapping and stroking to avoid excessive coverage that would result in runs, sags, or wrinkles.

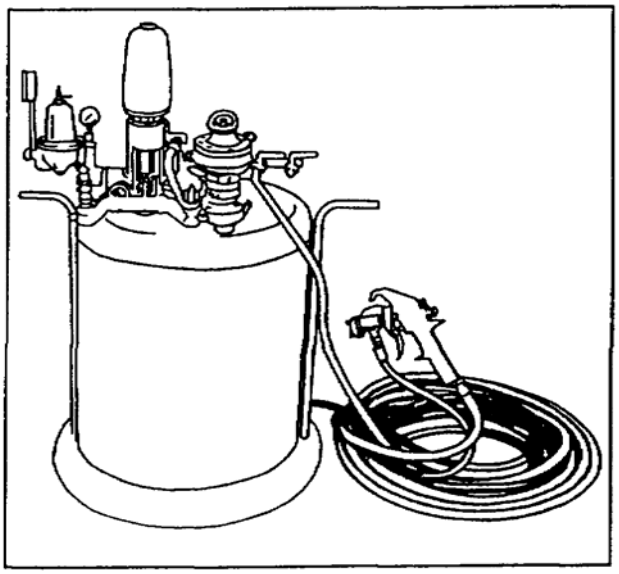

Figure 3-43. Airless spray system

An airless unit with a self-contained heater (Figure 3-44, page 3-36) is also available. The advantage of the hot sprayer is that it uses heat rather than thinner as the viscosity-reducing agent. As a result, the hot sprayer is very compatible with VOC regulations.

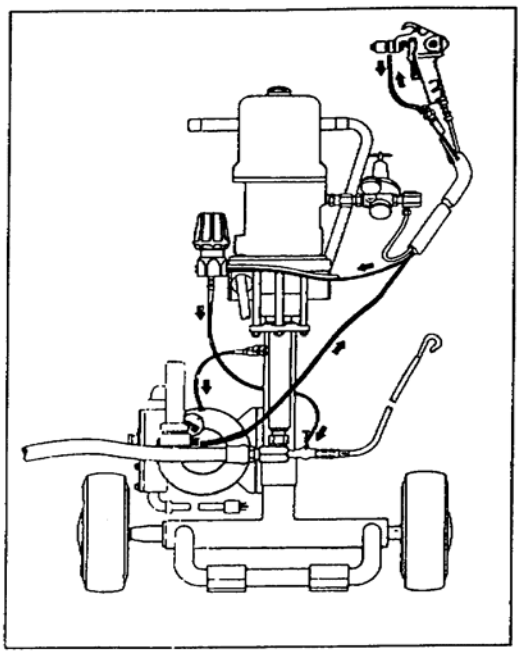

Figure 3-44. Airless hot spray system

c. The system shown in Figure 3-43, page 3-35, is operated by compressed air; however, some airless models and the hot sprayer are electrically operated. The generation of static electricity and proper daily maintenance are two primary concerns when airless-spray systems are used.

(1) Static electricity. It is possible for sparking to occur between a gun and the object being sprayed; this is due to a static-electrical potential that is generated by the high pressure necessary for airless spraying. Sparking can result in explosion and/or fire. To prevent sparking, ensure that both the object being sprayed and the airless equipment are grounded. Do this by attaching a static wire to ground. If the hose does not contain a static-electrical conductor, a static wire must be attached from the spray gun to a ground rod.

(2) Daily maintenance. Under no circumstances should paint be permitted to set up, settle out, or dry within the pump. Perform routine maintenance and cleaning daily by using the following steps:

Step 1. Lubricate the motor when the pump is operating and there are signs of moisture condensing on the cylinder wall during compression action. However, if an airline lubricator is installed, the motor should cause no trouble as long as the amount of oil used can be controlled.

Step 2. Wipe the inside of the container with a lacquer solvent-soaked rag. Coat the container with clear lacquer to inhibit rust. Solvent that is not compatible with lacquer may cause congealing.

Step 3. Shut off the air supply to the pump by turning the adjusting knob on the regulator counterclockwise until no spring pressure is felt. Remove pressure from the system by pulling the trigger on the gun, or remove pressure by opening the pressure-release valve on the fluid-strainer assembly and turning the valve clockwise.

Step 4. Detach the main air-supply hose from the stem at the regulator and attach the hose to the stem on the lift assembly. This lifts the pump assembly from the fluid container.

Step 5. Remove the fluid container, clean and fill it with approximately 1 gallon of clean solvent, and replace the pump assembly.

Step 6. Remove the spray cap and strainer assembly from the spray gun, and clean them with solvent.

Step 7. Detach the main air-supply hose from the stem on the lift assembly, and reattach the base to the stem at the regulator. The pump will lower back into the container.

Step 8. Close the pressure-release valve, if it was opened, to relieve the system pressure.

Step 9. Turn the adjusting knob on the regulator clockwise, just far enough so that the pump will operate slowly when the gun trigger is pulled.

Step 10. Aim the gun nozzle against waste material and hold the trigger back until the fluid in the pump, hose, and gun has been replaced by solvent.

Step 11. Aim the gun nozzle back into the solvent container, pull the trigger, and circulate the solvent in this manner until the fluid remaining in the system is suspended in solvent. The cleaning action will be better if the system pressure is increased at this point. Lift the inspection cap on the container-cover assembly and aim the nozzle into the container.

Step 12. Remove pressure from the system by pulling the trigger on the gun or remove pressure by opening the pressure-release valve on the fluid-strainer assembly and turning the valve clockwise.

Step 13. Turn the handle on the filter cartridge one full turn. Do not turn the handle while the filter is pressurized, or distortion of the unit cartridge will result. If the handle turns hard, it should not be forced but the unit cartridge should be removed for thorough cleaning.

Step 14. Repeat steps 4, 5, 7, 8, and 9.

Step 15. Open the pressure-release valve and allow the solvent to circulate for a few seconds.

Step 16. Repeat steps 3 and 4.

Step 17. Empty the fluid container and clean the exterior of the pump and container with a solvent-soaked rag.

Step 18. Wipe off the entire unit with a dry rag.

Step 19. Detach the hose connection from the stem on the lift assembly and allow the pump assembly to settle into the empty container.

Step 20. Turn off the air supply.

3-13. Stationary Compressor Unit. When compressed air is furnished by a large stationary compressor, incline the main air-line leading to the spray guns. Inclining the main line permits the condensed moisture from the compressed air to flow back into the air-pressure tank. Figure 3-45 shows the installation of a stationary compressor unit with the main line sloping toward the air compressor. In this manner, the water is drained by a drain cock which is located at the base of the air-pressure tank.

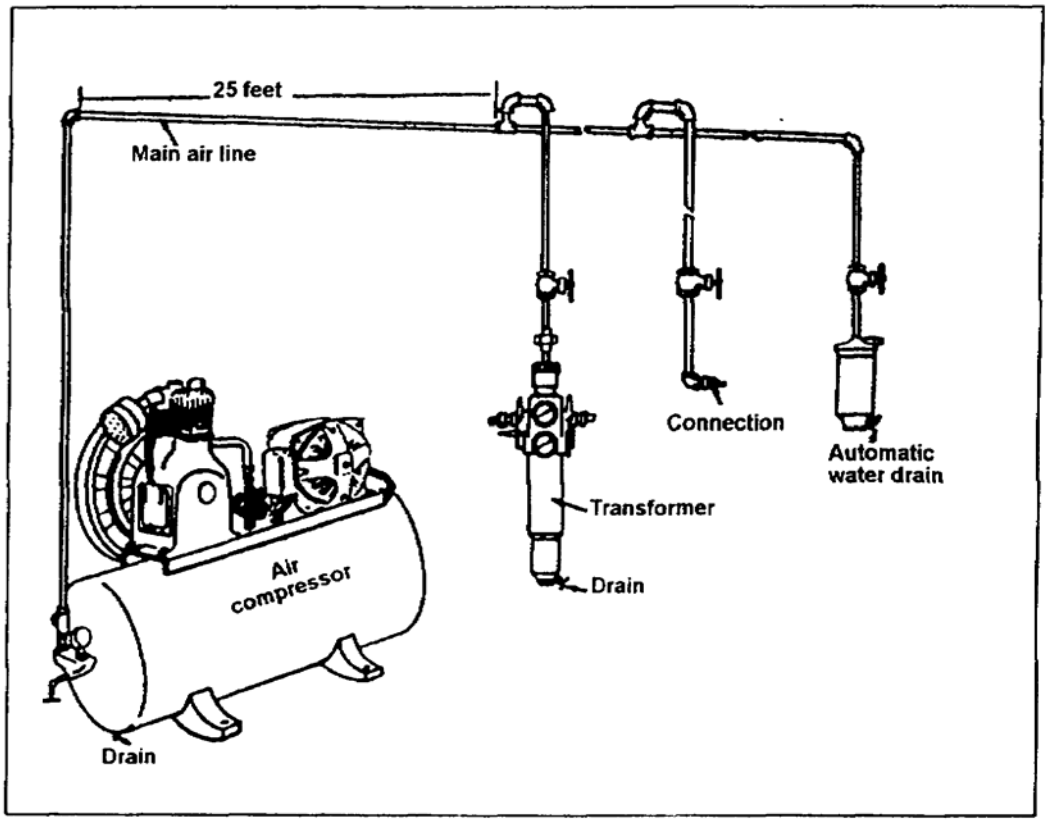

Figure 3-45. Stationary compressor unit

3-14. Air Transformer. Supply spray guns with clean, moisture-free, regulated air by installing an air transformer (Figure 3-46) in the main air-line. The air transformer separates oil, dirt, and water from the compressed air before it enters a spray gun; reduces the pressure on the main air-line to the desired working pressure; and provides convenient hose connections for one or more spray guns. The transformer has gauges which indicate the working pressures at the outlets.

Whenever an air transformer has only one working-pressure regulator, all attached spray guns will have the same working pressure. However, if the transformer has two working-pressure regulators, as shown in Figure 3-46, the attached spray guns are regulated by different working pressures. Use an air transformer in all finishing paint shops where a supply of clean, moisture-free, regulated air is required. When a regulated supply of air is available, a condenser is used to separate oil and moisture from the air. Conventional spray systems have basic similarities. There must be an adequate source of compressed air, a paint supply, and a spray gun for controlling the combination of air and paint in an atomized cloud against the surface to be coated.

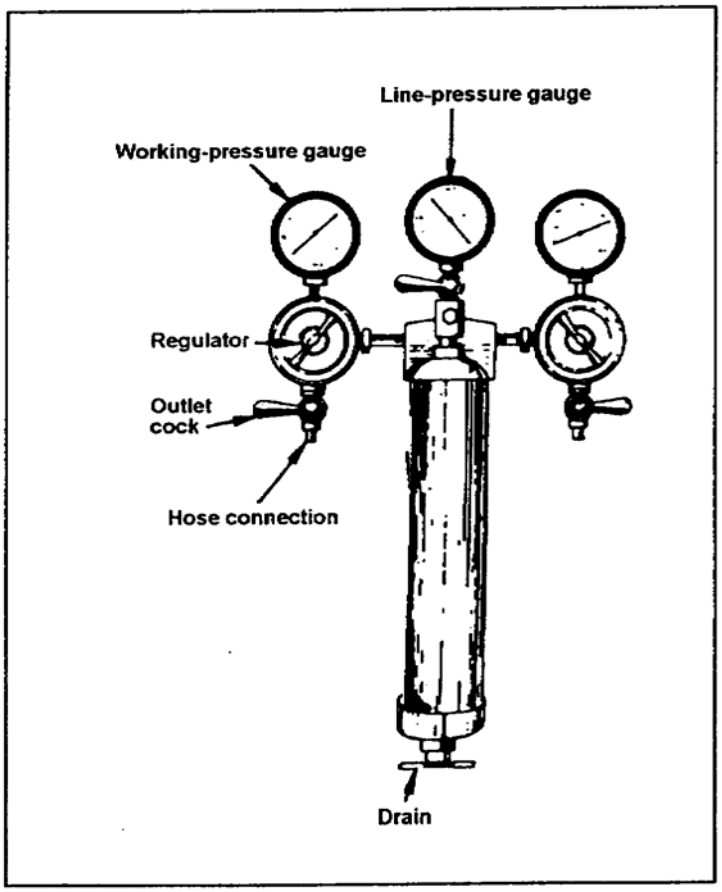

Figure 3-46. Air transformer

3-15. Spray Booth. A permanent spray-paint shop requires a well-ventilated and well-illuminated spray booth. Figure 3-47, page 3-39, shows a portable spray booth that is ventilated by the deflector plate shown in the back. It is illuminated by floodlights recessed in the walls of the booth. Portable floodlights should also be available for the

spray booth to provide good, direct light on the area being painted. All lights must be of the vaporproof type.

3-16. Wiping Rags and Drop Cloths. Carry wiping rags at all times to wipe up spills and splatters before they dry on unprotected surfaces. Drop cloths are used to protect furniture and floors and are available in canvas, rubberized fabrics, plastic, and impregnated paper. Plastic drop cloths are the most popular because they are inexpensive and can be discarded when they become soiled.

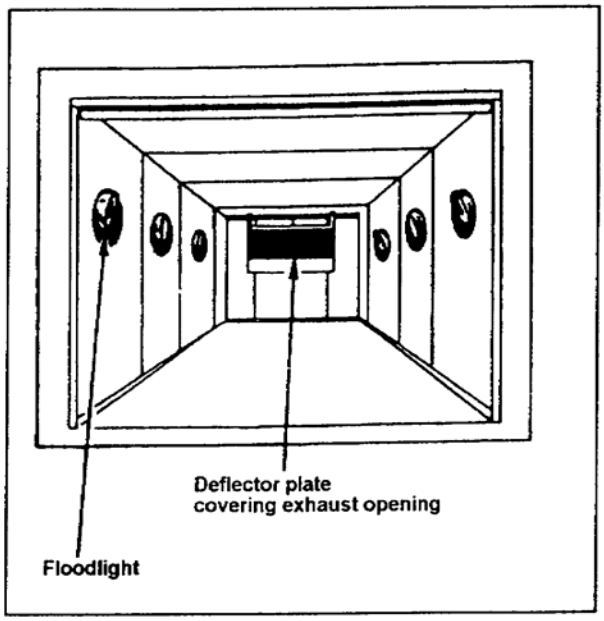

Figure 3-47. Portable spray booth

PART C: TRAFFIC-MARKING MACHINES

These machines are used to paint stripes on roads, parking lots, landing strips, and curbs. Although stripes can be painted by hand, a power-operated marker will save much time.

3-17. Construction Features.

a. Power-operated, traffic-marking machines differ in design and construction. Each manufacturer builds one or more power-operated machines to certain specifications; however, some machines do not have a traction drive. Such machines must be pushed by hand or pulled by a motorized truck or tractor. A few of the machines are designed to mount on motorized trucks; others are mounted on either three or four wheels, operate on their own power, and furnish power for traction.

b. A typical small, power-operated, self-propelled, traffic-marking machine is compact in construction and all the units are in plain view. The paint tank is located between the wheels, with the gasoline engine and air compressor are mounted over the

paint tank. The paint spray gun is located on the right front side. The bead-dispenser hopper is mounted in front and to the right of the engine and the compressor. A flexible hose connects the hopper with a rotating bead spreader. The front wheel furnishes the traction for the machine. Power is transmitted to the wheel from the engine by roller chains.

3-18. Uses. Traffic-marking machines are used to paint stripes and dispense glass beads into the wet paint in one operation. Depending on the make and model, machines may have any number of features, such as spray guns and bead dispensers.

a. Air Compressor. An air compressor may be a single- or twin-cylinder type and is capable of delivering ample air pressure. The safety valves are generally set at 75 to 100 pounds per square inch.

b. Paint Tank. A paint tank varies in capacity with the type of marking machine. Strain all paint before placing it into any paint tank. Paint-tank lids or covers are of the clamp-on type. Most paint tanks have a hand- or power-operated agitator which keeps the paint thoroughly mixed during the operation. This agitator is also used for cleaning the tank.

c. Paint Gun. A paint gun mounted on the traffic-marking machine has the same design as that used for ordinary spray painting. The spraying width is governed partly by the spray gun's adjustments and the distance the spray gun's nozzle is positioned from the surface being striped.

d. Bead-Dispenser Hopper. The hopper is a special mechanism that meters (measures out) and applies glass beads. The hopper's size depends on the traffic marker's size, and the hopper is driven by an auxiliary shaft. After the glass beads are metered by the dispensing mechanism in the ratio of 6 pounds to every gallon of binder, they are blown by air pressure into the wet binder stripe.

3-19. Operation Characteristics. Most traffic-marking machines are designed to handle any standard traffic-marking paint. They also spray lacquers and reflectorized synthetic materials (glass beads). Always use the reducing agent recommended by the paint manufacturer when it is necessary to thin traffic-marking paint; never use gasoline.

3-20. Operator Maintenance. Perform machine maintenance according to the directions set forth by the manufacturer. However, if such manuals are not available, the suggestions listed in the following paragraphs should be followed:

a. Gasoline Engine. Keep the lubricating oil in the crankcase at the proper level. Change the oil at intervals of 25 to 50 hours of operation. Renew the oil-filter cartridge when the oil is changed. Remove the air filter from the engine, disassemble the filter, and wash in cleaning solvent. Place new lubricating oil in the oil filter cartridge and reinstall the air filter.

b. Paint Tank. To clean the paint tank, first remove the tank cover and pour the paint into a disposable container. Then pour about a gallon of thinner into the tank. Replace the cover, let the fluid agitate for two or three minutes, and drain the fluid.

Remove the cover from the tank, and wipe it out with a clean cloth. This process will get most of the paint out of the tank. Replace the cover and pour enough thinner into the tank to cover the fluid outlet, which leads to the spray guns, and apply pressure to the spray gun on the tank. Open the compressor engine controls (this will apply pressure and force the thinner through the fluid line and spray gun). Drain the fluid that is left in the paint tank and remove the cover. Wipe out the tank and clean all external units.

3-21. Storage. When storing a paint gun or traffic-marking equipment, perform the following:

a. Paint Gun. Remove the gun, disassemble it, and clean the parts thoroughly after each use.

b. Bead Dispenser. Lubricate the dispenser's moving parts frequently.

c. Driving Units. Check belts and drive chains frequently for wear. Lubricate the chains, as required.

d. Wheel Bearings. Check the bearings for adjustment and lubricate them when necessary.

e. Tires. Inflate the tires to the proper pressures.

f. Grease Fittings and Oil Cups. Grease and oil various units by using the grease fittings and the oil cups provided for this.

g. Machine Storage. Store the machine in a sheltered place when it is not in use.

3-22. Glass Bead-Dispensing Gun. This gun is used whenever glass beads are to be embedded in traffic paint that has been applied with a paint brush or a spray gun instead of a traffic marker. The gun is actually an air pump, which is an accessory of the glass bead-dispenser hopper. When it is filled with glass beads and the handle is moved back and forth, the gun jets a uniform glass bead spray. For a light bead distribution, the gun is held so that the discharge chute is at the top, then as the gun is turned in a clockwise direction, the glass-bead distribution increases. These glass beads reflect light when applied to curbs, lane-markings, and runways.

3-23. Laminated-Backed Adhesive. Laminated-backed adhesive is another item used to mark traffic lanes so that they are easily seen at night. This material is flexible, may be cut to form such items as letters or numbers, and comes in various colors.

PART D: SIGN-MAKING EQUIPMENT

You will be called on very frequently to paint signs on ground equipment, parking lots, driveways, buildings, and almost everywhere imaginable.

3-24. Stenciling Equipment. There is a varied assortment of equipment available to do a professional stenciling job.

a. Stencil-Cutting Machines. Stencil-cutting machines may vary in appearance and size (1/4- to a 4-inch cutters). Each machine has a handwheel to position an indicator that designates the letter, number, or mark to be cut; and it has a cutting handle to depress. A portion of the stencil machine's rotating handwheel contains a punch, which is positioned under the cutter handle. The positioning of the indicator brings the punch in alignment with a die in the lower portion of the machine. Depressing the cutting handle forces the punch into the die, thus cutting the desired letter or number into the stencil board.

b. Stencil Board. Stencil board comes in two grades-high-wear resistance (grade 1) and moderate-wear resistance (grade 2). Grade 1 is available in 8- by 24-inch, 20-.by 32-inch, and 24- by 36-inch sheet sizes. Grade 2 comes in only one sheet size, 20 by 24 inches. The grade required for a job is determined by whether the stencil will be used only once or several times.

c. Stenciling Ink. While any suitable paint may be used to stencil, stenciling ink is a specific ink that will mark porous surfaces, wood and cardboard shipping containers, burlap, or canvas. This ink comes in black, white, and yellow.

d. Stencil Set (Brass). When a stencil-cutting machine is not available for use, a brass stencil set will produce a professional job. It is a good practice to have two or three sets of each size on hand, as many signs contain two or three of the same letter and it will save time if the complete sign is made at one time. The stencil set consists of brass numbers and letters that interlock to form the desired words and numbers. The set includes a container and the following stencils: a complete alphabet; numbers 0 to 9, one ampersand, one comma, one apostrophe, one period, one spacer, and four end pieces. The letters and numbers are gothic style and are available in 1-, 1 1/2-, 2-, 3-, and 4-inch sizes. You should disassemble the letters and numbers immediately after use and wash them in the same type of thinner used to thin the stencil paint.

e. Stencil Key Set. The stencil key set is used as a guide for laying out and drawing letters or numbers on stencil boards. A 3-inch stencil key set is shown in Figure 3-48, page 3-44. To use the stencil key set, first mark off a horizontal line on the stencil board. Then use the key set to outline the desired numbers or letters, using either the inside or outside of the set. After all the letters or numbers have been outlined on the stencil board, simply cut them out with a sharp knife or a one-sided razor blade.

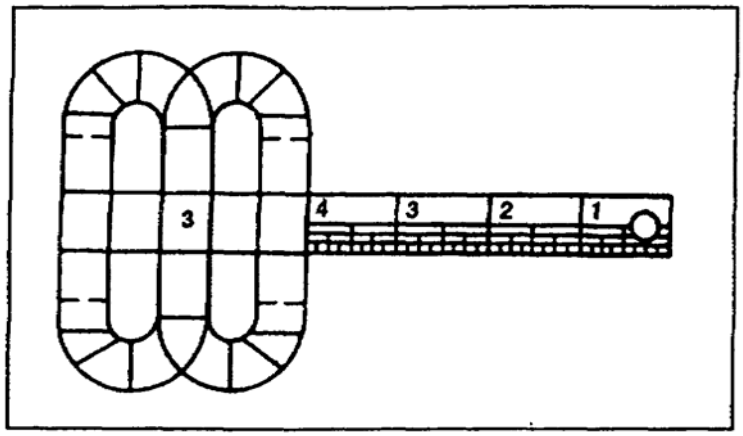

Figure 3-48. Stencil key set

f. Spray Gun. A stenciling spray gun (Figure 3-49) is desirable for stenciling. This gun is smaller than the one used for painting and is known as a touch-up gun. It is not mandatory to have a small stenciling spray gun in a shop; however, it is desirable to have at least one spray gun that can be used only for this purpose. It is usually convenient to have more than one cup for a spray gun when more than one stencil paint color is used. The extra cups facilitate spraying different paint colors. General care and maintenance for a stenciling spray gun are the same as previously described for the regular paint gun.

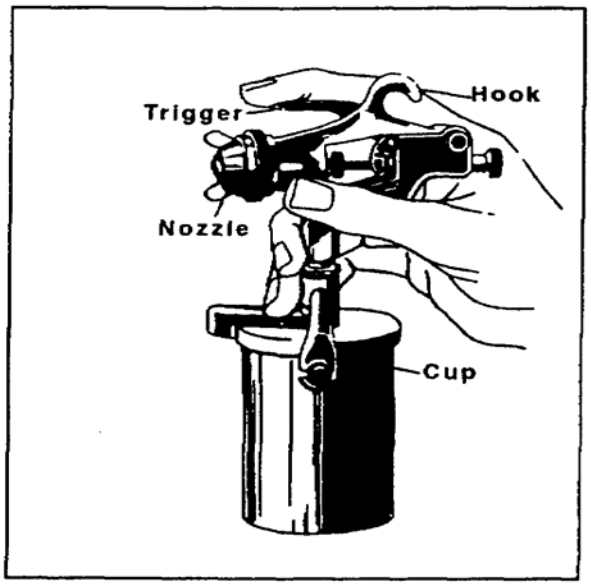

Figure 3-49. Stenciling spray gun

g. Layout Tools. Whether you are using a brass stencil set or a stencil board that you prepared with the stencil key set, you must lay out the stencil. The tools you need for this layout consist of a straightedge, a yardstick, a steel square, and dividers. Using whatever tools you need, position the stencil and secure it in place with masking tape.

h. Stencil Brushes and Rollers. Use stencil brushes or rollers on jobs where it would be impractical to use a spray gun. The most common brushes are the artist's stencil brush, the stencil brush, and the fountain stencil brush:

(1) Artist's stencil brush. This brush is round with black bristles placed in a long, polished, cedar handle. The bristles are held in place by a metal ferrule. The diameter at the ferrule is 1/2 inch, and the bristle length is 1 inch.

(2) Stencil brush. This brush is made of 100 percent hog bristles, with the flag ends cut. It has a long, wood handle and comes in 13/16- by 15/16-inch and 1 1/16- by l 1/16-inch sizes.

(3) Fountain stencil brush. This brush has a reservoir handle. The leakproof reservoir holds a minimum of 2 ounces of stencil ink. The bristles extend 1 1/2 inches beyond the metal ferrule. A shutoff is provided between the reservoir and the brush to adjust the flow of stencil ink as well as to shut it off completely.

(4) Stencil roller. A roller measuring about 2 inches wide and 1 1/2 inches in diameter is sometimes used to stencil. The roller is rolled over a small amount of paint that is spread out on a glass or metal sheet. Then the paint-coated roller is rolled over a stencil to make the sign.

i. Pressurized Spray Can. A pressurized spray can is another item used for stenciling small signs. The cans are easy to use and come in various colors. The chief advantage of these cans is that there is no cleanup after you complete the job.

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LESSON 3

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only one correct answer for each item. When you have completed this exercise, check your answer with the key that follows. If you answer any item incorrectly, study again that part which contains the portion involved.

1. Several large pieces of equipment are encrusted with grease and dirt. Before you can paint them, you must first clean them with a/an _____.

   A. Vacuum cleaner

   B. Buffer

   C. Abrasive blaster

   D. Steam cleaner

2. Why should you have two or three sets of brass stencils with you when you are stenciling signs?

   A. Paint quickly builds up on brass

   B. Signs contain duplicate letters

   C. Extra sets avoid cleaning a stencil after each use

   D. Stencil letters easily bend out of shape

3. Which tool should you use to sharpen a cold chisel?

   A. Grinding wheel

   B. File card

   C. Wood rasp

   D. Emery abrasive

4. You are selecting a new abrasive wheel to put on a portable power grinder. The safe-operating speed of the new wheel is indicated _____.

A. On the wheel blotter

B. In the tool crib

C. In the applicable TO

D. On the spark plug

5. Which abrasive would you use to remove paint from a metal door?

A. Flint paper

B. Garnet paper

C. Aluminum oxide

D. Rottenstone

6. The airless spray gun develops a high pressure that presents the danger of sparking between the gun and the object to be sprayed. What precaution do you take?

A. Spray only during low humidity

B. Ground both gun and object

C. Wear shock-resistant rubber gloves

D. Use an explosive-proof motor

7. You have put a push-broom handle into the handle of a roller coater. The push-broom handle _____.

A. Provides more leverage

B. Allows the coater to get into corners easily

C. Applies more paint in one movement

D. Reaches high places without using scaffolds

8. You must paint a large gymnasium. Which tool do you use for volume painting?

   A. Stencil sprayer

   B. Self-contained spray gun

   C. Pressure-fed gun

   D. Low-pressure spray unit

9. Which tool do you use to clean rust from a protruding bolt head?

   A. Grinder

   B. Steam cleaner

   C. Disc sander

   D. Descaler

10. Which machine should you use to sand a drywall joint?

   A. Edger

   B. Buffer

   C. Vibrator sander

   D. Disc sander

11. You are using a compressor with a gasoline engine. When should you change the oil filter?

   A. When the oil is renewed

   B. After every job

   C. When the dipstick shows 1 quart low

   D. When the gas tank is filled

12. To remove excess paint from your brush while you are painting, the brush should be _____.

A. Wiped with a dry cloth

B. Tapped against the inside of a paint container

C. Wiped over the rim of a paint can

D. Rubbed on a hidden part of the job

13. Glass beads are added to traffic-marking paint to _____.

A. Decrease the amount of paint work

B. Increase the paint durability

C. Improve the base coat

D. Reflect the light

14. A good-quality paintbrush should have what key feature?

A. Bristles that are flagged

B. A metal handle

C. Bristles with two rows

D. Bristles made of horsehair

15. Which machine would you use to spray a small area with quick-drying lacquer?

A. Low-pressure air compressor

B. High-pressure air compressor

C. Suction pump

D. Vibrator pump

16. You are applying layers of paint on fine woodwork. What should you use to smooth the finish between paint coats?

A. Grit abrasive

B. Pumice stone

C. Paint file

D. Paint scraper

17. You are running a power-operated, traffic-marking machine. You can partly control the paint-spray width by the _____.

A. Gun nozzle type being used

B. Thumbscrew on the paint tank

C. Drive pulley's speed

D. Gun nozzle's distance from the pavement

18. What type of spray gun would you connect directly to a small compressor?

A. Internal mixer

B. Bleeder

C. Nonbleeder

D. Suction feeder

LESSON 3

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer	
1.	D.	A steam cleaner consists of a metal cabinet that houses such components as an electric motor or gasoline engine and units for individual water, soap, and heating systems. The detergent and spray, together with impact (friction) caused by high velocity, loosen and remove dirt and encrustations. (page 3-18, para 3-2h)
2.	B.	It is a good practice to have two or three sets of each size on hand, as many signs contain two or three of the same letters and it will save time if the complete sigh is made at one time. (page 3-43, para 3-24d)
3.	A.	Chisels are sharpened by grinding their heads on a grinding wheel to restore the bevel, which is usually at a 60- to 70-degree angle. Occasionally, you may need to remove the burrs from the heads if the heads have mushroomed. (page 3-5, para 3-le)
4.	A.	You should use reinforced abrasive wheels and never exceed the operating speed indicated on the wheel blotter. (page 3-15, para 3-2d)
5.	C.	Aluminum oxide is backed with production paper, and is used on wood and light-weight metal surfaces because aluminum oxide's tough coating cuts faster and longer than flints. (page 3-6, para 3-1g)
6.	B.	It is possible for sparking to occur between a gun and the object being sprayed, this is due to a static-electrical potential that is generated by the high pressure necessary for airless spraying. Sparking can result in explosion and/or fire. To prevent sparking, ensure that both the object being sprayed and the airless equipment are grounded. Do this by attaching a static wire to ground. If the hose does not contain a static-electrical conductor, a static wire must be attached from spray gun to a ground rod. (page 3-36, para 3-12c[1])
7.	D.	The handles of industrial rollers are designed to accommodate a push-broom or dust-mop handle so floors can be painted without kneeling and ceilings and high places can be reached without the use of scaffolds. (page 3-29, para 3-6c)
8.	C.	This spray gun will spray heavy paints or materials when supplied with a low air volume. It is considered one of the best general-purpose guns for use with regular paints. Since no siphoning effect is necessary for pressure application, it is the tool for volume painting. (page 3-30, para 3-70

9. D. This tool is good for cleaning hard-to-get-at areas on metal surfaces, such as grooves, corners, crevices, rivets, protruding nuts or bolts, and gratings. (page 3-16, para 3-2e)

10. C. This tool is excellent for removing old paint and varnish and for sanding drywall joints. (page 3-12, para 3-2b[1])

11. A. In addition, the oil in the crankcase must be changed; and if the engine has an oil filter, the filter cartridge is changed when the oil is renewed. (page 3-34, para 3-11lb)

12. B. Never rub bristles over the edge of a container to remove excess materials, as this procedure tends to wear or break the bristles. Instead, tap the brush lightly against the inside of the container above the paint level. (page 3-23, para 3-5a)

13. D. These glass beads reflect light when applied to curbs, lane-markings, and runways. (page 42, para 3-22)

14. A. The bristles of good-quality paintbrushes are flagged at the ends to hold and help spread paint; where as, poor-quality paintbrushes will neither hold paint well or spread it evenly. (page 3-20, para 3-4a)

15. C. This spray gun is ideal for spraying small areas with lacquer, varnish, or other light materials. (page 3-30, para 3-7e)

16. B. There are three powdered abrasives: pumice stone, rottenstone, and jeweler's rouge. Powdered abrasives are used primarily on furniture for fine-woodwork finishing, to smooth the finishes between coats of paint, and to polish metal surfaces. (page 3-9, para 3-1g[3])

17. D. The spraying width is governed partly by the spary gun' adjustments and the distance the spray gun's nozzle is positioned from the surface being striped. (page 3-41, para 3-18c)

18. B. This spray gun is constructed in such a way that air passes through it at all times. This feature prevents excessive pressure buildups in the compressor. Use this type if the spray gun is to be connected directly to a small compressor. (page 30, para 3-7c)

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LESSON 4

LADDERS, SCAFFOLDS, AND HOISTING EQUIPMENT

OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn about the basic principles of ladders, scaffolds, and hoisting equipment and their use.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will learn to describe how ladders, scaffolds, and hoisting equipment are used and how to safely operate them.

CONDITION: You will be given the material contained in this lesson.

STANDARD: You must complete the lesson and the practice exercise.

REFERENCES: The material contained in this lesson was derived from the TM 5-800 series, FM 5-125, and MIL-STD 1212.

INTRODUCTION

You should know how to select and erect ladders and scaffolds to reach an area that cannot be reached from the ground. Safety is of prime importance in the erection and use of ladders and scaffolds. The number of serious accidents caused by scaffolds and ladders that are not erected or used properly far exceeds those from other sources. Improper use or assemblage of scaffolds or ladders not only endangers you, but it is also a potential death trap for anyone under the items.

PART A: LADDERS

4-1. Ladders. Ladders are devices that are used to gain access to work that is performed at higher levels. It is possible to paint the entire exterior surface of a one- or two-story building from a ladder; however, it is often more comfortable and timesaving If a scaffold is erected. Ladders are of several types: single rung, extension, step, and trestle. Each ladder is designed for a specific use and should not be used for any other purpose. Ladders are made of magnesium, aluminum, steel, or well-seasoned wood which is free of knots or other defects.

a. Single-Rung Ladder. A single-rung ladder consists of two side rails that measure from 8 to 30 feet in length. Between the side rails, rungs (steps) are spaced 12 inches apart. Each rung is capable of supporting weights up to 500 pounds. The size of a ladder is determined by its overall length. Although single-rung ladders are available in lengths of up to 30 feet, it is better to avoid ladders that are over 20 feet because of the difficulty in raising them. Figure 4-1 shows a typical single-rung wood ladder. To help keep the bottom of the ladder from slipping, it is necessary to equip it with ladder safety shoes or spikes (Figure 4-2).

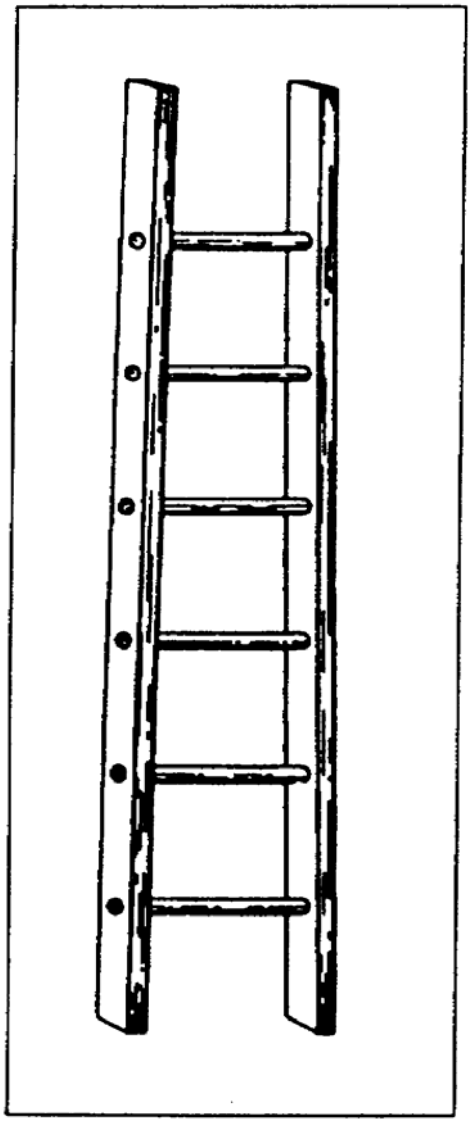

Figure 4-1. Single-rung woodladder

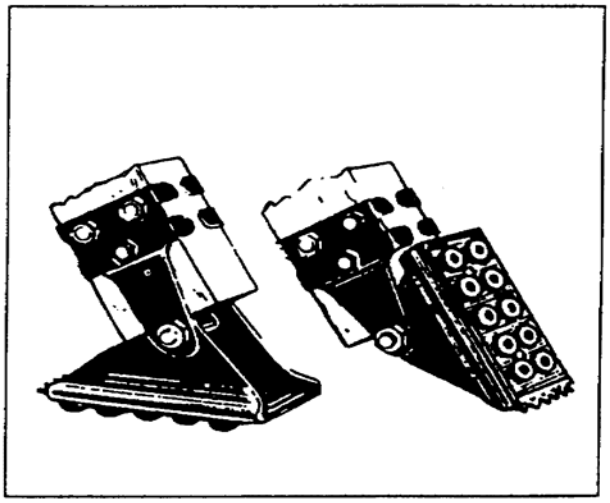

Figure 4-2. Ladder safety shoes

(1) Selecting a ladder. Ladder selection depends on the height at which you must work. You will work most efficiently in a space not higher than shoulder level nor lower than knee level. The length of a ladder is critical because the area that you can safely reach is limited. Use a ladder that is long enough for you to reach your work without climbing past the third rung from the top of the ladder.

(2) Raising and placing a ladder. To raise a ladder (Figure 4-3), place the ladder base against the foundation of the building, raise the top end of the ladder, and walk under it toward the building. As soon as the ladder is perpendicular, pull the ladder bottom out from the building to a distance of one-fourth of the working length of the ladder (Figure 4-4). If it is necessary for you to get on top of a building, the ladder must extend at least 30 inches above the eaves. The ideal ladder angle is about 70 degrees, this is shown on the far right of Figure 4-5, page 4-4. At this angle, the feet of a 28-foot ladder touches the ground about 72 inches from the building. The ratio is 1 foot away from the wall for every 4 feet of the ladder's height.

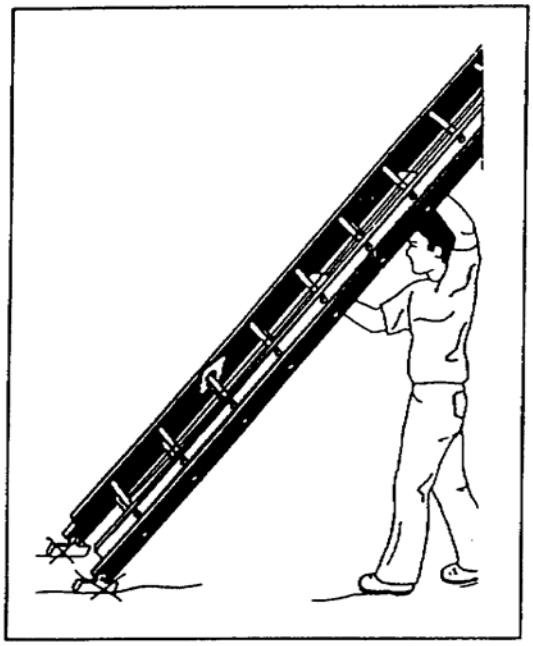

Figure 4-3. Raising a ladder

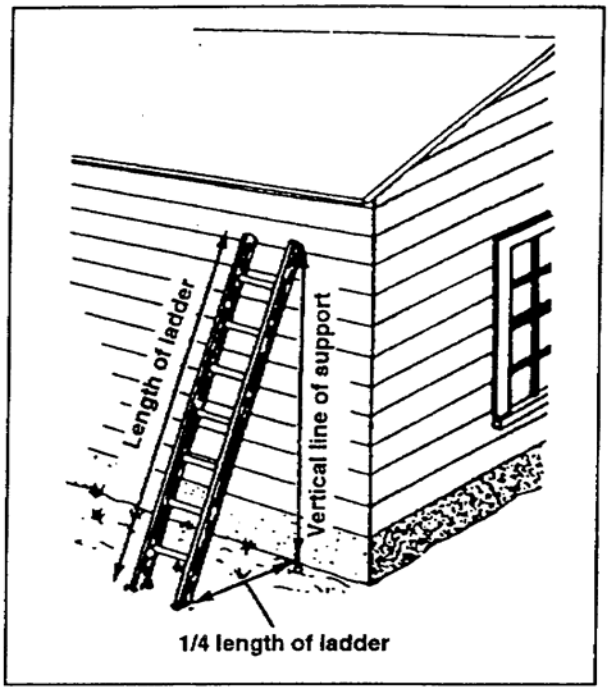

Figure 4-4. Placing a ladder properly

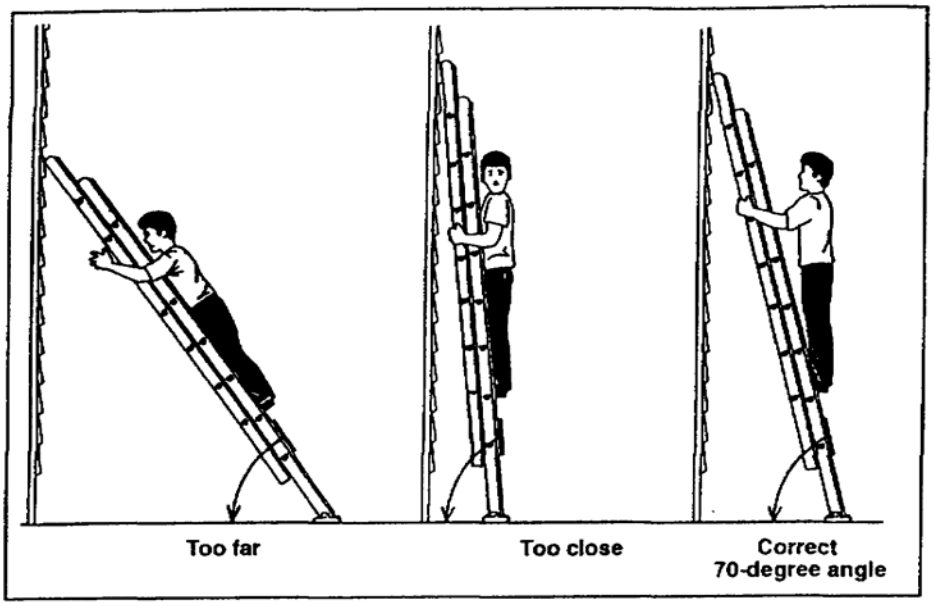

Figure 4-5. Getting the right ladder angle

(3) Lowering a long extension ladder. Lowering a long extension ladder requires a helper. To do this, follow the steps as shown in Figure 4-6. In step 1, a helper (shown on the left side of the ladder) braces the ladder foot. As the helper balances the ladder, you need to move out to catch the ladder at its midpoint. In step 2, the helper slowly lowers the ladder as you move toward the top end of the ladder. In step 3, catch the falling ladder and stabilize it by moving quickly toward the top rungs of the ladder.

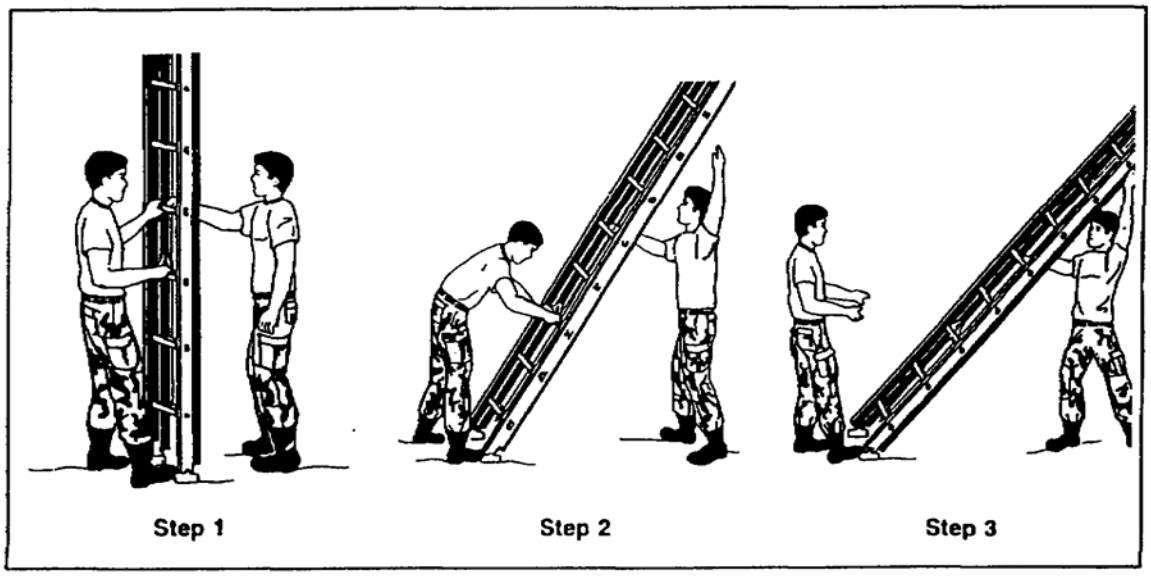

Figure 4-6. Lowering a long extension ladder

(4) Carrying a ladder. When carrying a ladder, use your arms to stabilize it then carry the ladder horizontally at waist-height (Figure 4-7). A long ladder may require two people to carry it.

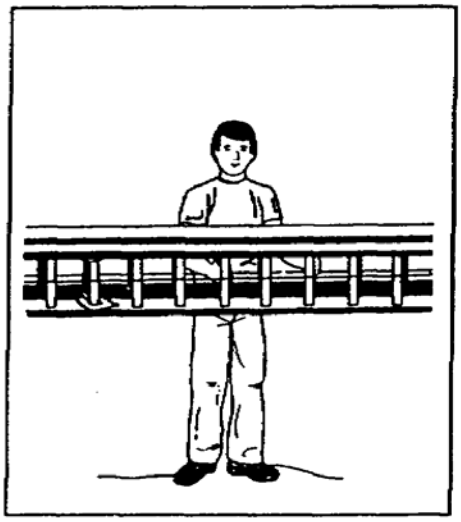

Figure 4-7. Carrying a ladder

(5) Using extension planking and ladder jacks. Two ladders may be adapted to hold a scaffold board or extension planking by using one steel ladder jack (Figure 4-8) for each ladder. Mount the jack on the front or back side of the ladder. By placing the ladder jacks between the ladder and the building being painted, you can work closer to the wall. Extension planking (Figure 4-9, page 4-6) is made of well-seasoned material that is straight-grained and free of any knots or defects. Extension planking is available in various sizes and is constructed so that its length is adjustable. As shown in Table 4-1, page 4-6, the size of the lumber used for planking depends on the scaffold span. A scaffold board made of lumber that is straight-grained and free of knots or any other defects may be used in place of an extension planking.

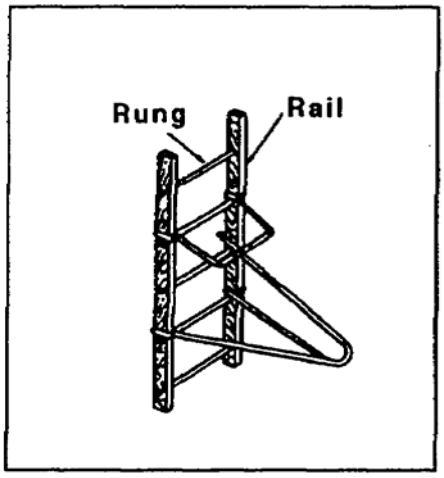

Figure 4-8. Steel ladder jack

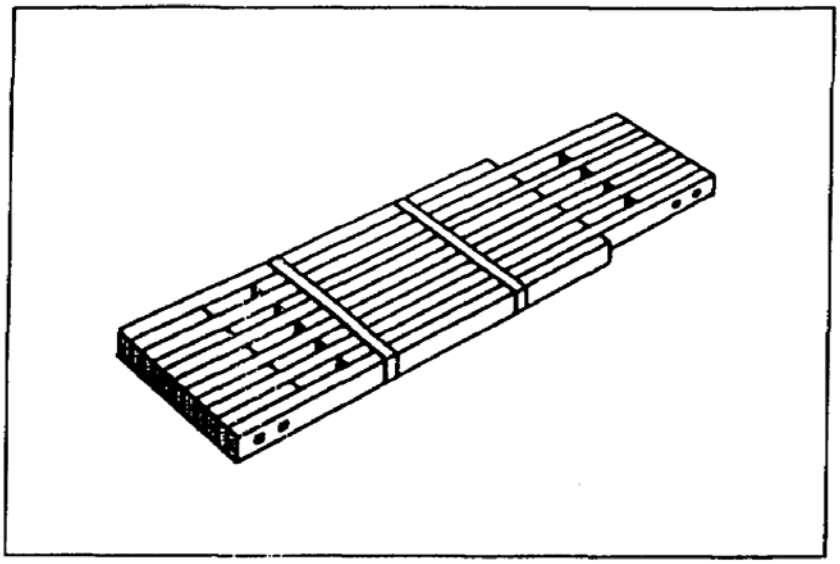

Figure 4-9. Extension planking

Table 4-1. Sizes of extension planking

Planking Size (*Inches*)	Maximum *Permissible Span* (Feet)
2 by 8	8
2 by 10	10
2 by 12	12
2 by 14	14
2 by 16	16
2 by 20	20
3 by 10	20

b. Extension Ladder. An extension ladder (Figure 4-10) consists of two or more sections that are adjustable to various lengths. The ladder sections are adjusted by pulling on a rope that is reeved (threaded) through a pulley. The pulley is mounted on the ladder's stationary section, and a rope is attached to the ladder's extension section. The extension ladder overlaps to hold the sections together. The sections will overlap at least 3 feet for ladders up to 38 feet long, 4 feet for ladders up to 45 feet long, and 5 feet for any extension ladders over 45 feet long. Lock the rungs of one ladder section to another section with a secure locking device. Ensure that the ladder sections are in the down position, then erect the extension ladder in the same manner as a straight ladder. After the ladder is erected, lean the top away from the building and raise it to the desired height with the pulley and rope arrangement. Ensure that the ladder sections are locked in place before ascending the ladder.

c. Stepladder. Use a stepladder (Figure 4-11) on flat surfaces where secure footing is obtainable. A stepladder is available in lengths up to 20 feet. Ensure that the brace is extended and locked when erecting a stepladder.

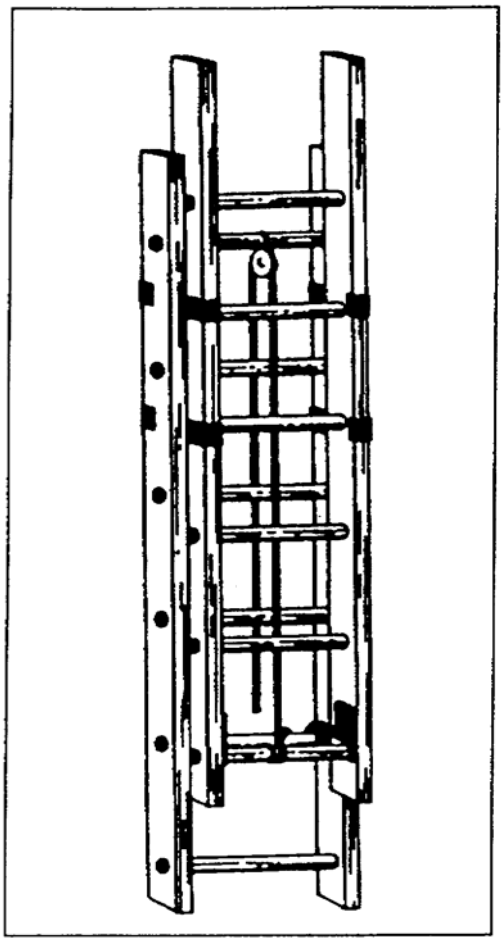

Figure 4-10. Extension ladder

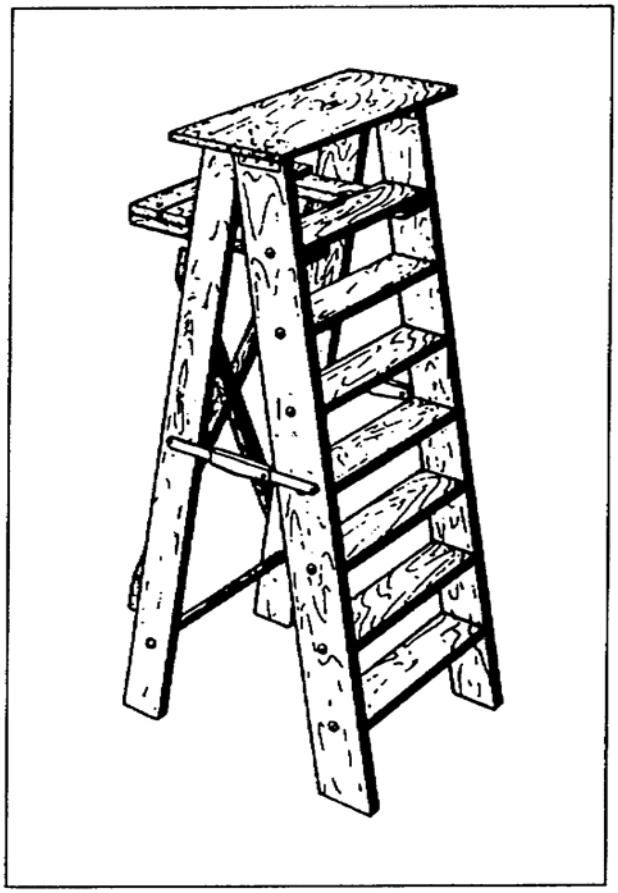

Figure 4-11. Stepladder

d. Trestle Ladder. A trestle ladder consists of two single ladders that are hinged at the top to form an A-shaped device. Erect two trestle ladders and extend planking or an extension platform between the rungs of the two ladders to form a painter's trestle (Figure 4-12, page 4-8).

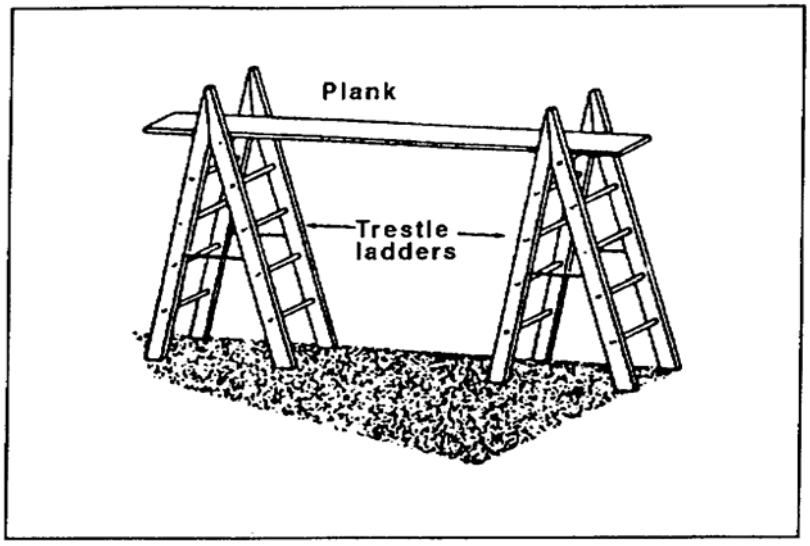

Figure 4-12. Painter's trestle

e. Ladder Care and Safety. You must keep ladders clean and free from dirt and paint. Protect wood ladders against weather with coats of shellac, varnish, or linseed oil. Do not paint wood ladders because it would hide any obvious defects. Before each use, you should ensure that the locking devices are secure on step and extension ladders. When ladders are not in use, store them in a sheltered, well-ventilated place that is away from weather elements. To prevent warping, hang ladders on brackets by the ladder's side rails. Observe the following additional safety precautions when using a ladder:

- Do not use a stepladder as a substitute for a workstand.
- Always face the ladder and hold on to each side rail when you are ascending or descending a ladder.
- Rope off the area around the ladder, fasten the ladder securely, and assign a man to steady the bottom of the ladder when the security of a ladder is endangered by other activities.
- Block off the doors and route personnel to another exit when you use a ladder in front of doors that open toward the ladder.
- Do not leave an erected ladder unattended for any length of time; instead, take the ladder down and lay it on the ground.
- Stand no higher than the third rung from the top when working on a ladder.
- Do not attempt to reach beyond your normal arm's length while using a ladder.
- Do not allow anyone on the ladder with you. If the work requires additional help, the helper should get another ladder.

- Tie the ladder to something solid with a rope when there is any danger of the ladder slipping. Ladders that are equipped with safety shoes are still subject to slipping.

- Do not place a ladder on a movable object.

- Do not climb a ladder while using both of your hands to hold material; at least one hand must be used while you are ascending or descending a ladder.

- Do not place the top or the bottom of a ladder against unstable material.

PART B: SCAFFOLDS

4-2. Scaffolds. Scaffolds are temporary elevated platforms that are used to support workers and tools. They may range from individual planking that is placed across structural members of a building to steel mobile work platforms. Well-constructed or erected scaffolds are safer for you to work from than a ladder. The types of scaffolds most commonly used by painters include horse, independent metal, swing stage, and boatswain's chair.

a. Scaffold Horse. Use a scaffold horse (Figure 4-13) to construct a simple scaffold. Scaffold horses are used in pairs; however, a stairway, porch, or any other stationary object may be used to hold one end of a work platform while a scaffold horse holds the other. Before each use, check the nailing of the horse's legs and braces.

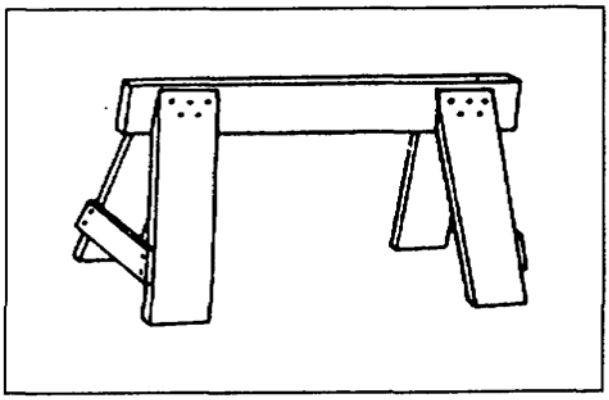

Figure 4-13. Scaffold horse

b. Independent Scaffold (Figure 4-14, page 4-10). A double-pole, built-up scaffold (metal or wood) is completely independent of the main structure. Several types of patented independent scaffold are available for simple and rapid erection. Brace the scaffold uprights (scaffold legs) with diagonal members, and cover the working level with a planking platform. All bracing must form triangles, and the base of each column requires adequate footing plates (Figure 4-15, page 4-11) for the ground-bearing area. If the ground is fairly even, secure the footing plate by bolting it to a 2-by-8 board that is placed on the ground.

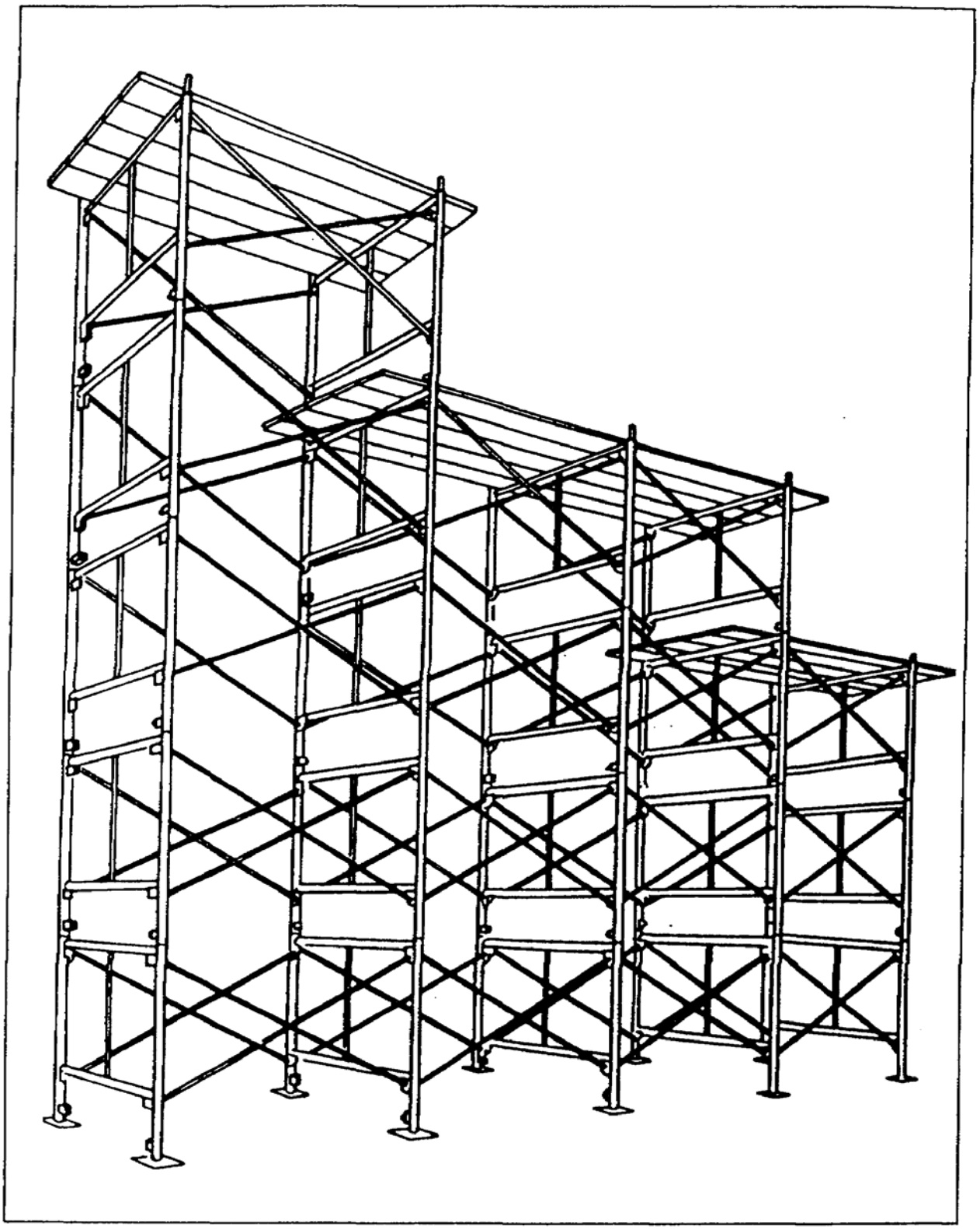

Figure 4-14. Independent scaffold topped with platforms

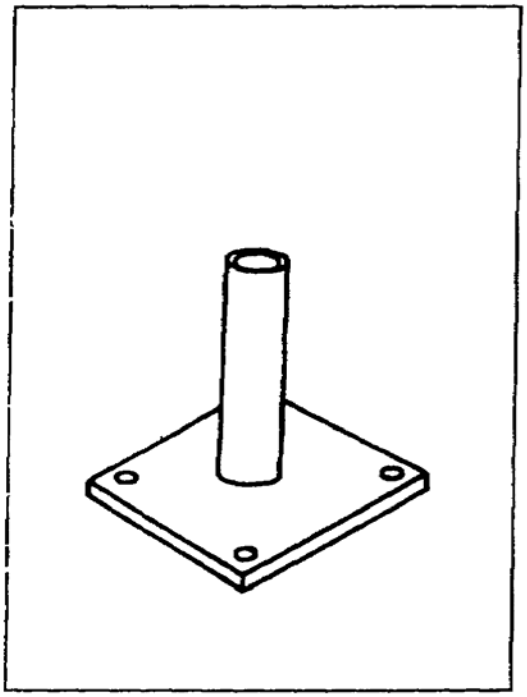

Figure 4-15. Footing plate

(1) Patented steel scaffold. Erect patented steel scaffolds by placing the first and second uprights on footing plates and insert diagonal braces, thus completing the first set of tiers. The diagonal braces have rapid locking end fittings (Figure 4-16) that permit rapid locking into position. The first-tier set is set at ground level on steel bases. Erect the second-tier set by placing the third and fourth uprights on footing plates and insert diagonal braces. Lock the second set to the first set with diagonal braces. Elevate scaffolds by placing a second tier on the first tier, and lock the bottom of each upright to the top of the lower tier. Build the scaffold as high as desired, but tie a high scaffold into the main structure with building tie-ins (Figure 4-17, page 4-12).

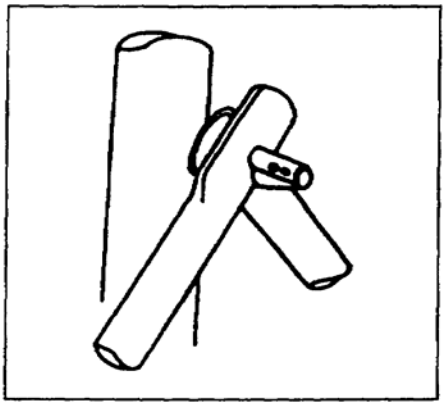

Figure 4-16. Rapid-locking end fitting

(2) Side bracket. A side bracket (Figure 4-18) is damped on the scaffold uprights to provide platforms at various height levels.

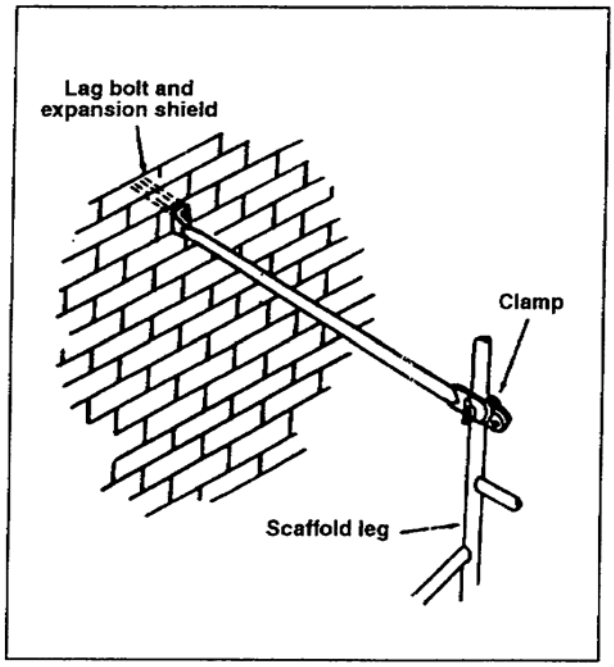

Figure 4-17. Building tie-in

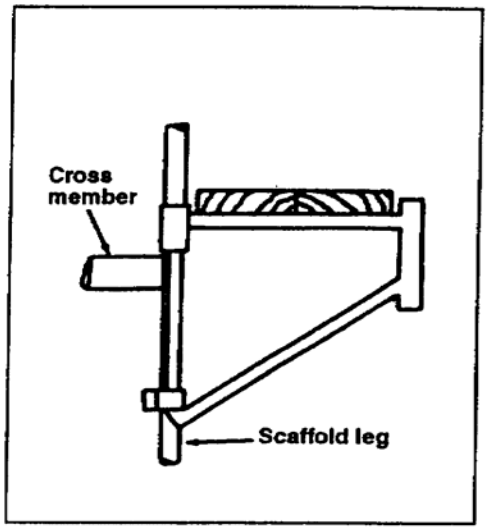

Figure 4-18. Side bracket

(3) Rolling tower. Use a rolling tower if the scaffold will be subjected to frequent moves; however, use a rolling tower only on solid floors. To construct a rolling tower, replace the scaffold footing plates with locking casters. For safe operation, the tower's height must not exceed four times its smallest base dimension; in addition, the tower must have a guardrail above the working platform.

c. Swing-stage scaffold. A swing-stage scaffold (Figure 4-19) is used to reach the upper surfaces of an exterior wall, and it is suspended from the building's roof or cornice with ropes or steel cables. The scaffold consists of the following parts: two block-and-tackle sets, two cornice hooks, two swing stirrups, a guardrail, and a platform.

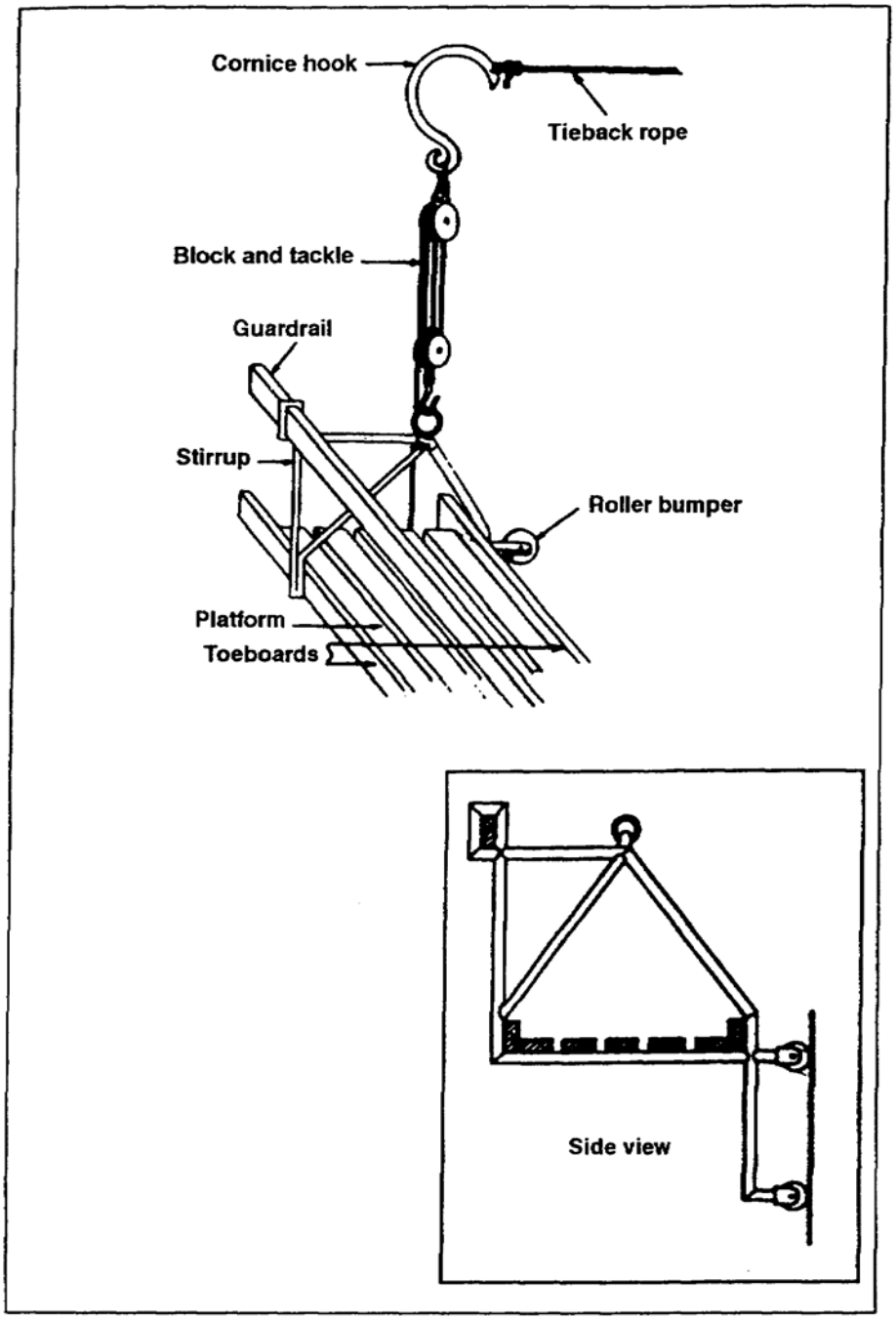

Figure 4-19. Swing-stage scaffold

(1) Cornice hook. A cornice hook is a large metal hook that hooks securely over the top of a substantial portion of the building's roof or cornice. Fasten one end of a tieback rope to an eye located at the top of the hook. For your safety when working on scaffolds, you should fasten the other end of the tieback rope to the base of a chimney, a soil pipe, or any other securely attached projection that will support the weight of the scaffold and the

working load being placed on it. Attach a set of block and tackle to an eye which is located at the lower end of a cornice hook.

(2) Stirrup. A stirrup is a metal unit that supports the scaffold's platform. Two stirrups are required for the scaffold. Attach a set of block and tackle to a ring located at the top of each stirrup. Use rollers to prevent the scaffold from hitting the wall.

(3) Guardrail. A guardrail is constructed of 2- by 4-inch material, and it helps to protect you from falling from the scaffold platform.

(4) Platform. A scaffold platform is the working space on which you move about as you work. It is from 20 to 24 inches wide and no greater than 26 feet long. A platform is made of well-seasoned, 2-inch lumber that is straight-grained, and free of knots or other defects.

(5) Toeboards. Use toeboards to prevent material from slipping or accidentally being knocked off the scaffold. Toeboards run the full length of the scaffold, are constructed of 2- by 4-inch material, and are located at the front and back of the scaffold.

(6) Block and tackle. To raise and lower the unit a special type of block and tackle is used on each end of the swing-stage scaffold. A hoisting machine may be substituted for the block and tackle.

(7) Safety. Observe the following salty rules when using swing-stage scaffold:

- Test the scaffold before using it by hoisting it 1 foot off the ground, then load it with four times the working load.
- Prevent the scaffold from swinging outward after hoisting by lashing it to a building or a structural wall as soon as possible.
- Ensure that no more than two painters work on the scaffold at one time. Each painter should wear a safety belt that is attached to an individual lifeline. Fasten the safety-belt line above and free from the scaffold.
- Use steel cable whenever possible when using acid solutions with hoisting equipment. Immediately replace all fiber ropes exposed to acids or acid solutions.
- Lower the scaffold to the ground when it is not in use.
- Keep weights on the outside of a platform when raising the scaffold until it is secured to the building.
- Do not touch the wall next to the scaffold until the scaffold is secured to the building. A light push against the wall may swing the scaffold out in such a way that you may lose your balance and fall.
- Check the hoisting machine's operation before each use.

- Inspect the tackle-block assembly before each use.
- Lubricate the tackle-block pulley wheels when necessary.
- Keep tackle-block ropes under cover to guard the ropes against deterioration when weather threatens.
- Do not expose tackle-block ropes to acids. Ropes exposed to acids will deteriorate and become unsafe.
- Do not permit tackle-block ropes to scrape against sharp projections such as scaffolds, windowsills, beams, or building walls.
- Ensure that the ropes are not pinched between hard surfaces when ropes are subjected to heavy loads.
- Do not run ropes through sheaves that are too small because the sheave's size will increase the wear on ropes.
- Lubricate the ropes with beef tallow when required.
- Do not allow ropes to slip over pulley wheels that do not turn.
- Inspect hooks for cracks or bends before using them again when cornice hooks have been subjected to strain.
- Inspect each plank before its use when planking is used as a part of a scaffold.
- Always inspect swing-stage stirrups before each use.
- Do not walk under a scaffold.
- Do not reeve a set of blocks on the ground where dirt, dust, or mud will get on the ropes.
- Do not use a scaffold without a guardrail.

(8) Inspection. Before each use, inspect all units that form a part of the scaffold and the units used in conjunction with the scaffold. You should inspect-

- Wooden platforms, guardrails, toeboards, metal stirrups, and hooks for worn parts.
- Steel cables for wear signs, kinks, worn parts, broken wires, or corrosion.
- Fiber ropes for any strands that are broken, cut, or weakened.

(8) Storage. Store scaffolds in a dry place to prevent the warping or splintering of wood sections; the rusting of wire cables, tackle blocks, or hoisting machines; or the rotting of fiber ropes.

d. Boatswain's Chair.

(1) The boatswain's chair shown in Figure 4-20 is made to support one man. Use the chair to paint small areas that cannot be reached by ladders or where it is impractical to erect scaffolds. A double bowline knot is used to make up the chair. For short periods of time, the chair can be used without the notched board by inserting your legs through the loops.

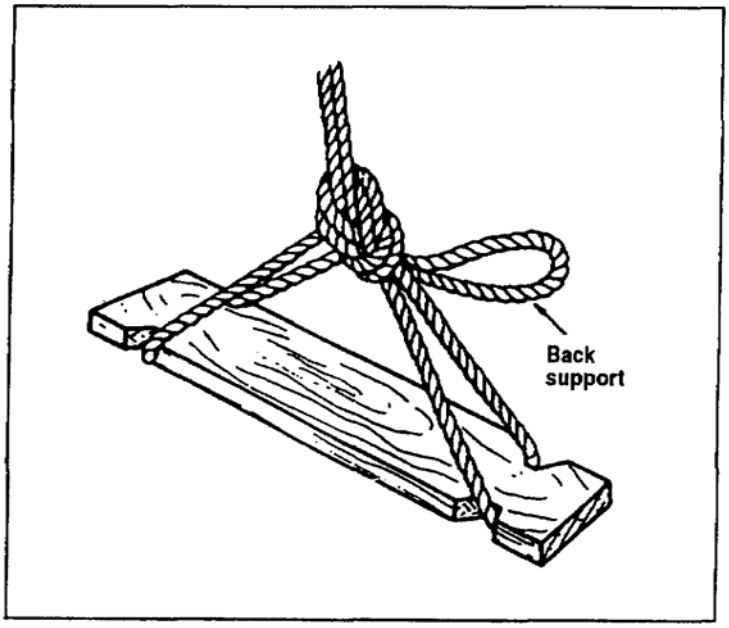

Figure 4-20. Boatswain's chair

(2) The boatswains chair with suspending tackle (Figure 4-21) is supported by securing block and tackle to the building's roof, ceiling joists, or rafters. Before using the chair, ensure that it is attached securely. You can either raise or lower yourself or be assisted by a person on the ground. When working alone, the fall line (control) is attached to the suspending tackle (two double blocks) with a rolling hitch. The fall line allows you to lower yourself. When receiving assistance from the ground, the fall line should be tied to a tree or a building member that will hold your weight.

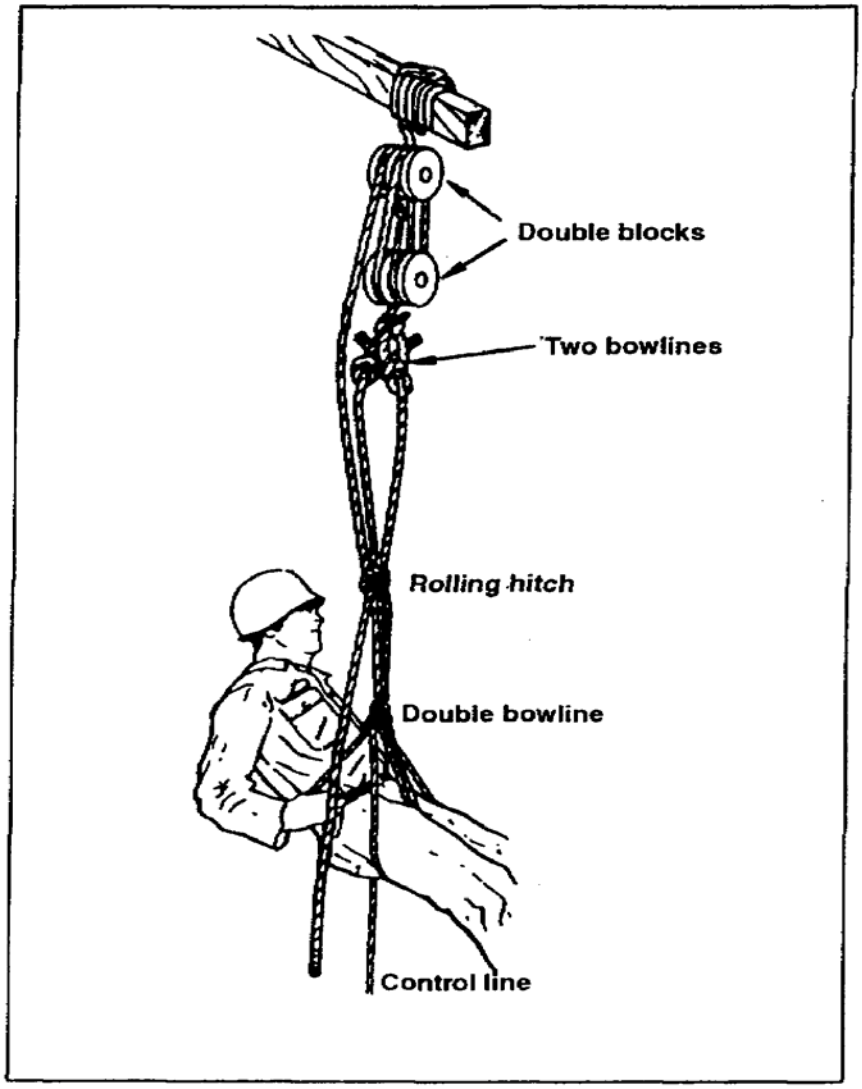

Figure 4-21. Boatswain's chair with suspending tackle

PART C: HOISTING EQUIPMENT

You must know how to tie simple knots, use block and tackle, and operate hoisting equipment efficiently and safely.

4-3. Knots and Hitches. Knots and hitches are used in many ways to tie equipment, materials, scaffolds, and many other items to block and tackle in order to raise or lower items, as needed. Some of the most commonly used knots and hitches are discussed below:

a. Square Knot. A square knot (Figure 4-22, page 4-18) is used to tie two ropes of equal size together so they will not slip and are easily untied. Note that the square knot, the running end and standing part of one rope come out on the same side of the bright that is formed by the other rope. The square knot will not hold if the ropes are set or if they are of different sizes. It tightens under strain but can be untied by grasping the ends of the two brights and pulling the knots apart.

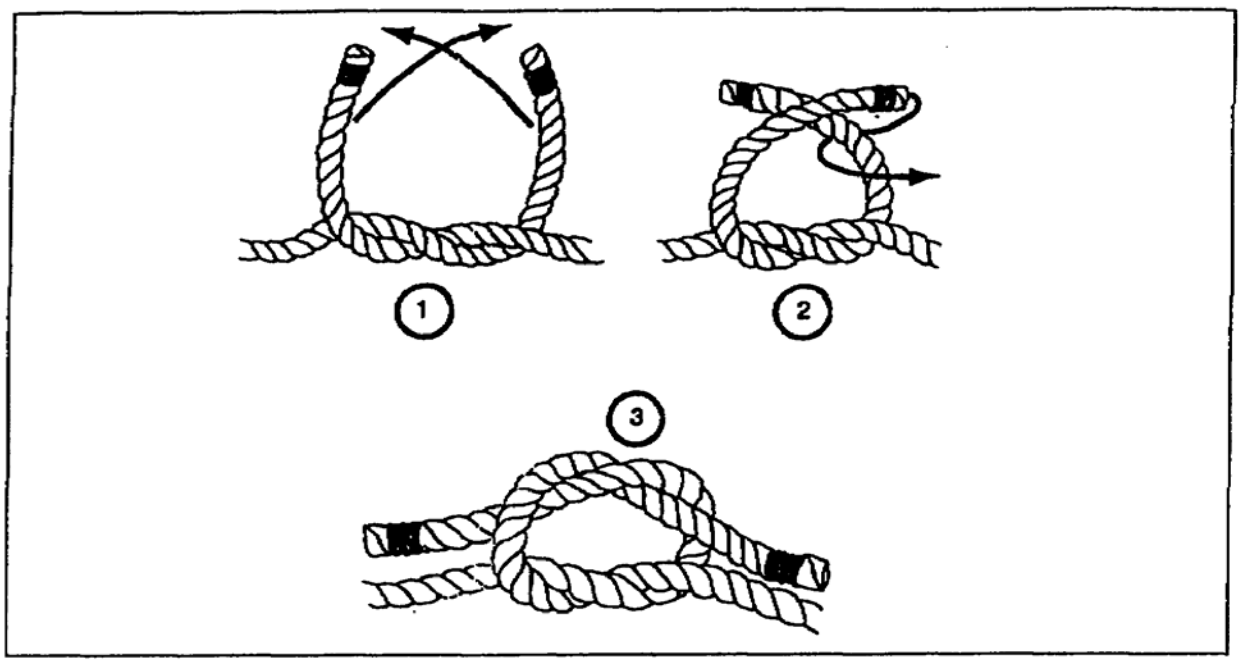

Figure 4-22. Square knot

b. Bowline. The bowline (Figure 4-23) is used to form a single loop that will not tighten or slip under strain and can be easily untied. It is one of the most common knots and has a variety of uses, one of which is the lowering of men and material.

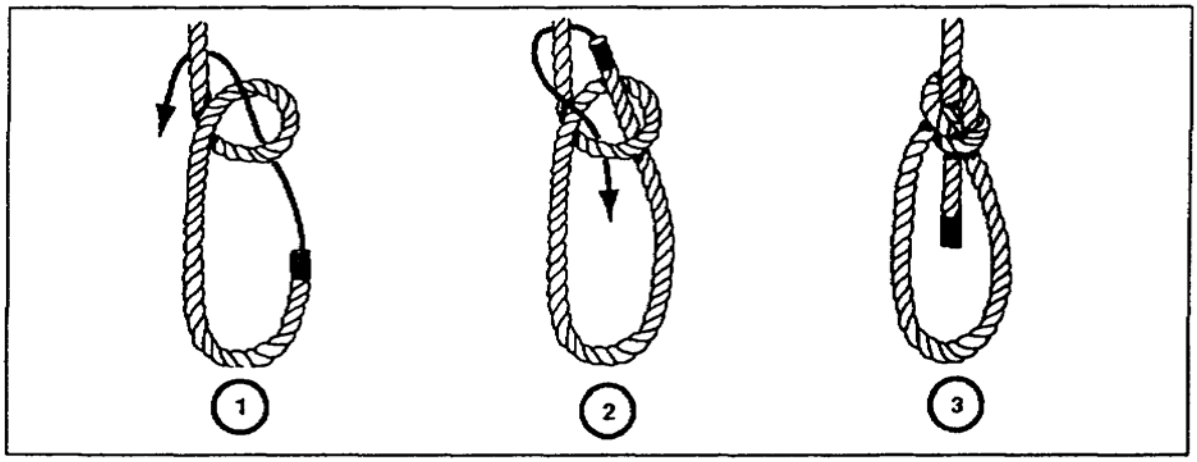

Figure 4-23. Bowline

c. Running Bowline. The running bowline (Figure 4-24) forms a strong running loop. It is a convenient form of running an eye. The running bowline provides a sling of the choker type at the end of a single line. Use it when tying a handline around an object at a point that you cannot safely reach, such as the end of a limb.

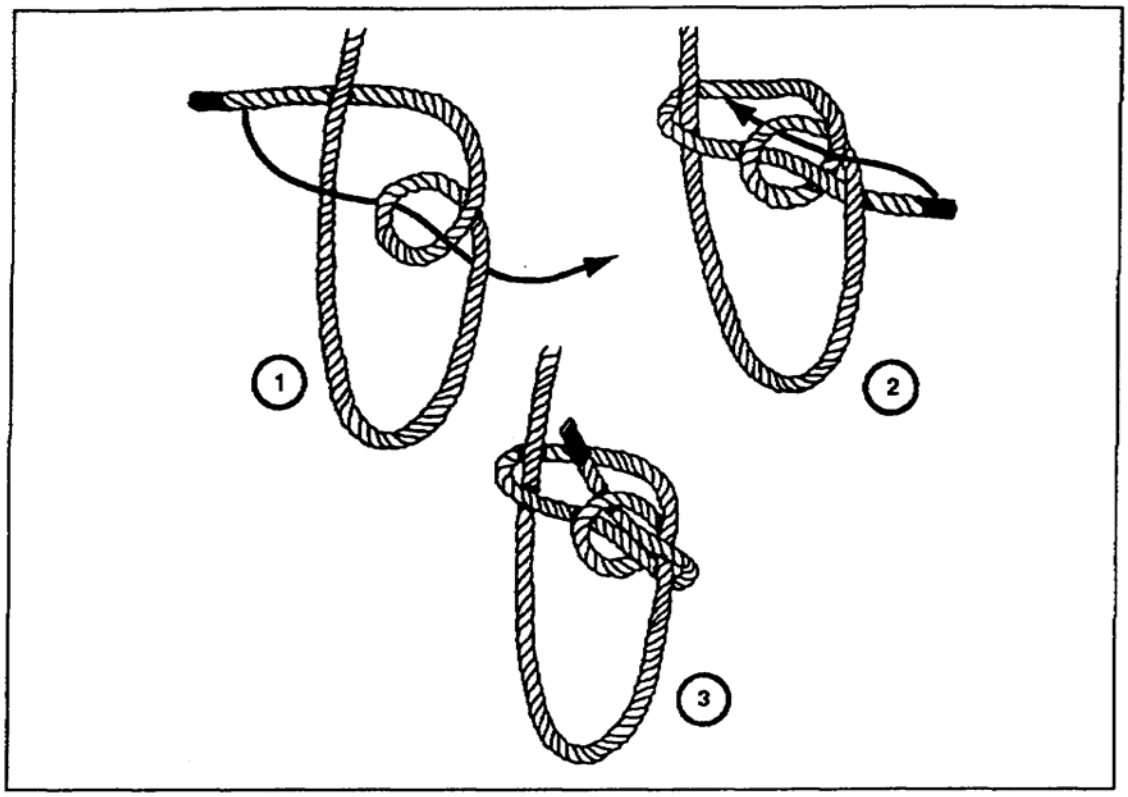

Figure 4-24. Running bowline

d. Double Bowline. The double bowline (Figure 4-25, page 4-20) forms three nonslipping loops. Use this knot to sling a man. As he sits in the slings, one loop supports his back and the remaining two loops support his legs. A notched board that passes through the two loops makes a comfortable seat known as a boatswain's chair discussed previously.

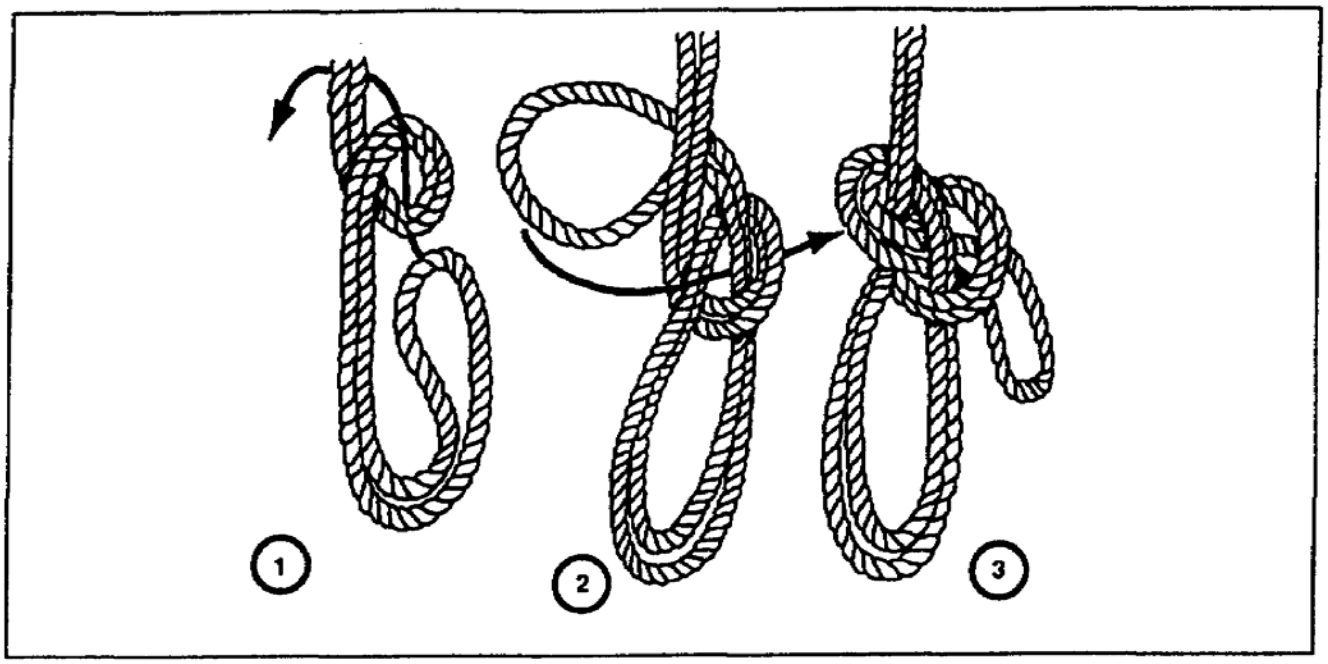

Figure 4-25. Double bowline

e. Two Half Hitches. Two half hitches (Figure 4-26) are used when there is a need for a quick way to tie a rope to a timber. Two half hitches are especially useful for securing the running end of a rope to the standing part. If the two hitches are slid together along the standing part to form a single knot, the knot becomes a clove hitch.

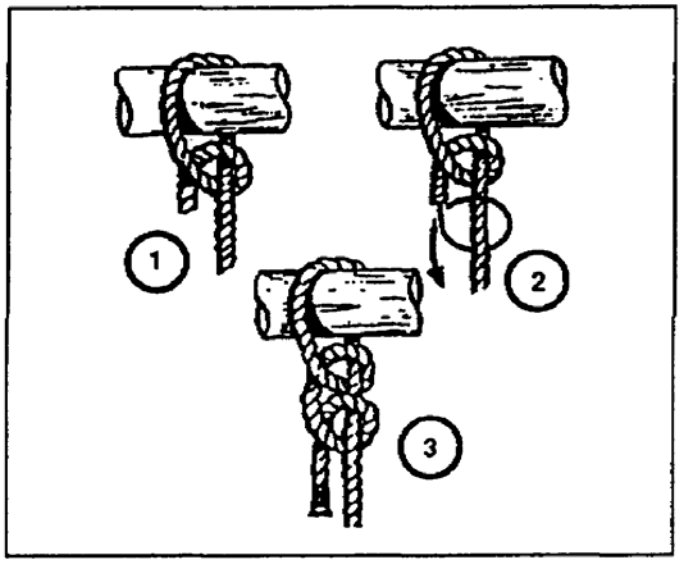

Figure 4-26. Two half hitches

f. Clove Hitch. A clove hitch (Figure 4-27) is one of the most widely used knots. You can use it to fasten a rope to a timber, pipe, or post. You can also use it to make other knots. This knot puts very little strain on the fibers when the rope is put around an object in one continuous direction. You can tie a clove hitch at any point in a rope. If there is not constant tension on the rope, another loop (round of the rope around the object and under the center of the clove hitch) will permit a tightening and slackening motion of the rope.

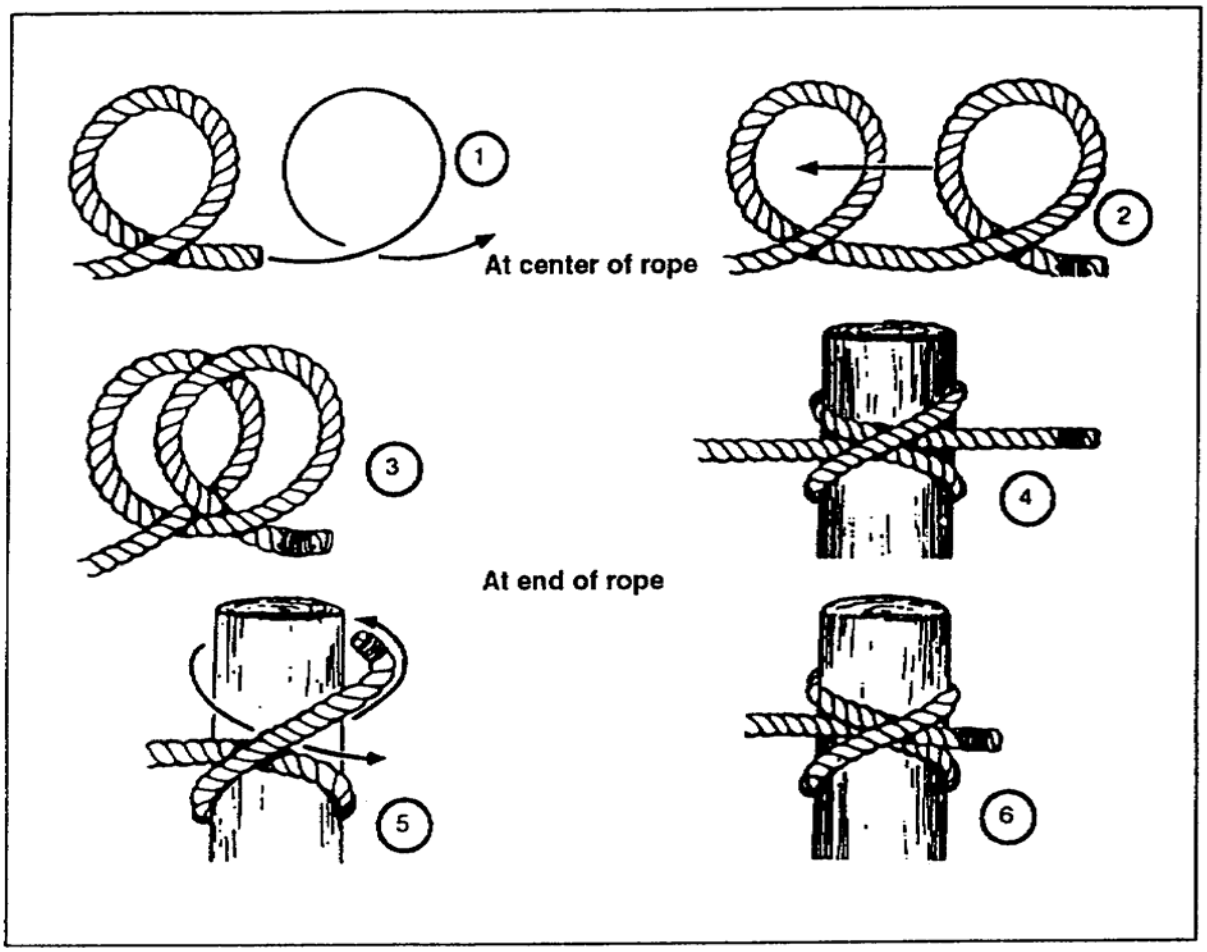

Figure 4-27. Clove hitch

g. Timber Hitch and Half Hitch. A timber hitch and half hitch (Figure 4-28, page 4-22) are combined to hold heavy timber or poles when they are being lifted or dragged. A timber hitch used alone may become untied when the rope is slack or when a sudden strain is put on it.

h. Round Turn and Two Half Hitches. Another hitch used to fasten a rope to a pole, timber, or spar is a round turn and two half hitches (Figure 4-29, page 4-22). For greater security, seize the running end of the rope to the standing part. This hitch does not jam.

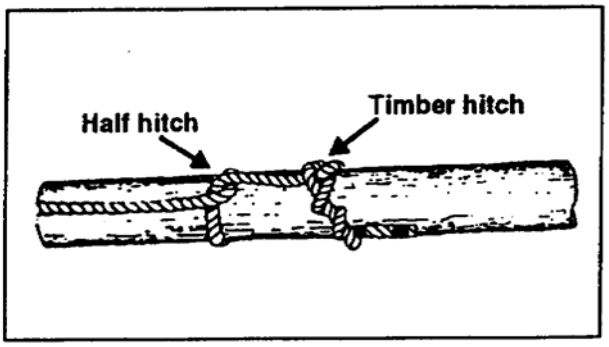

Figure 4-28. Timber hitch and half hitch

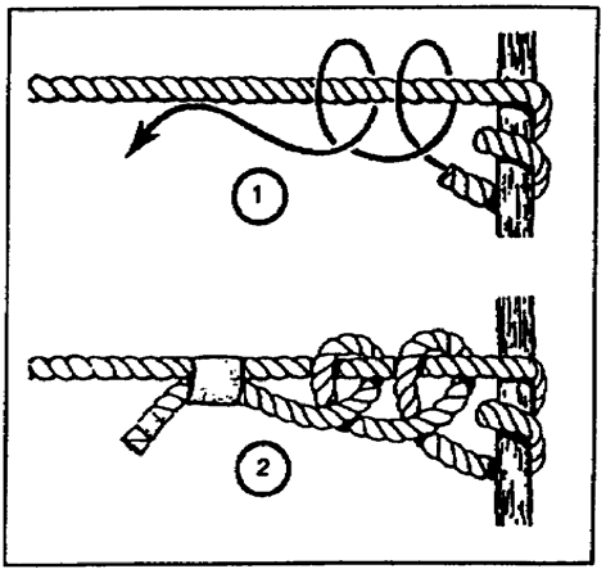

Figure 4-29. Round turn and two half hitches

i. Rolling Hitch. The rolling hitch (Figure 4-30) is used to lower a load slowly. The boatswains chair is another important use of the hitch. You can lower yourself by releasing the pull on the fall line and rolling the knot.

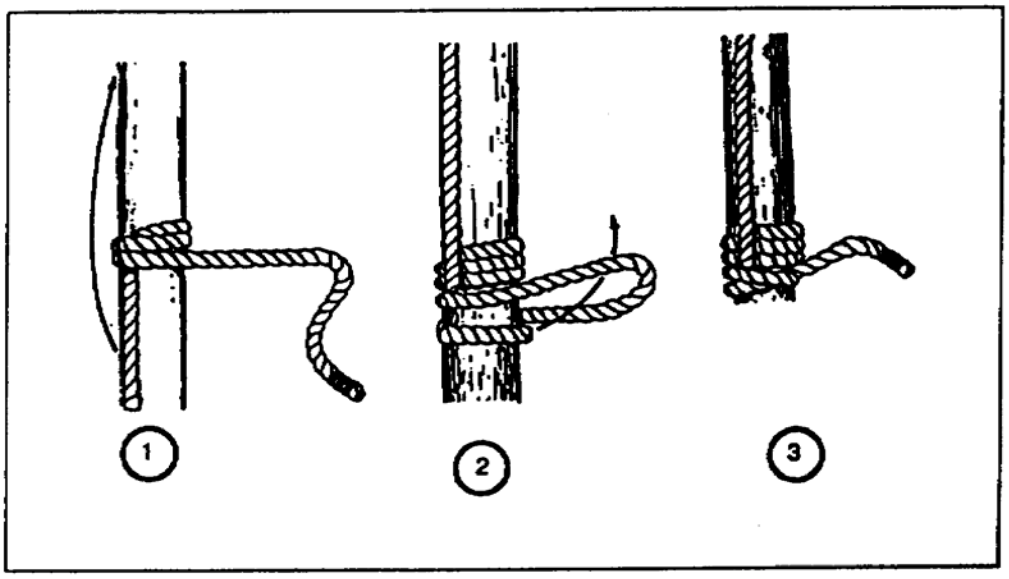

Figure 4-30. Rolling hitch

j. Scaffold Hitch. A scaffold hitch (Figure 4-31) is used to support the end of a scaffold planking with a single rope. The hitch prevents the planking from tilting.

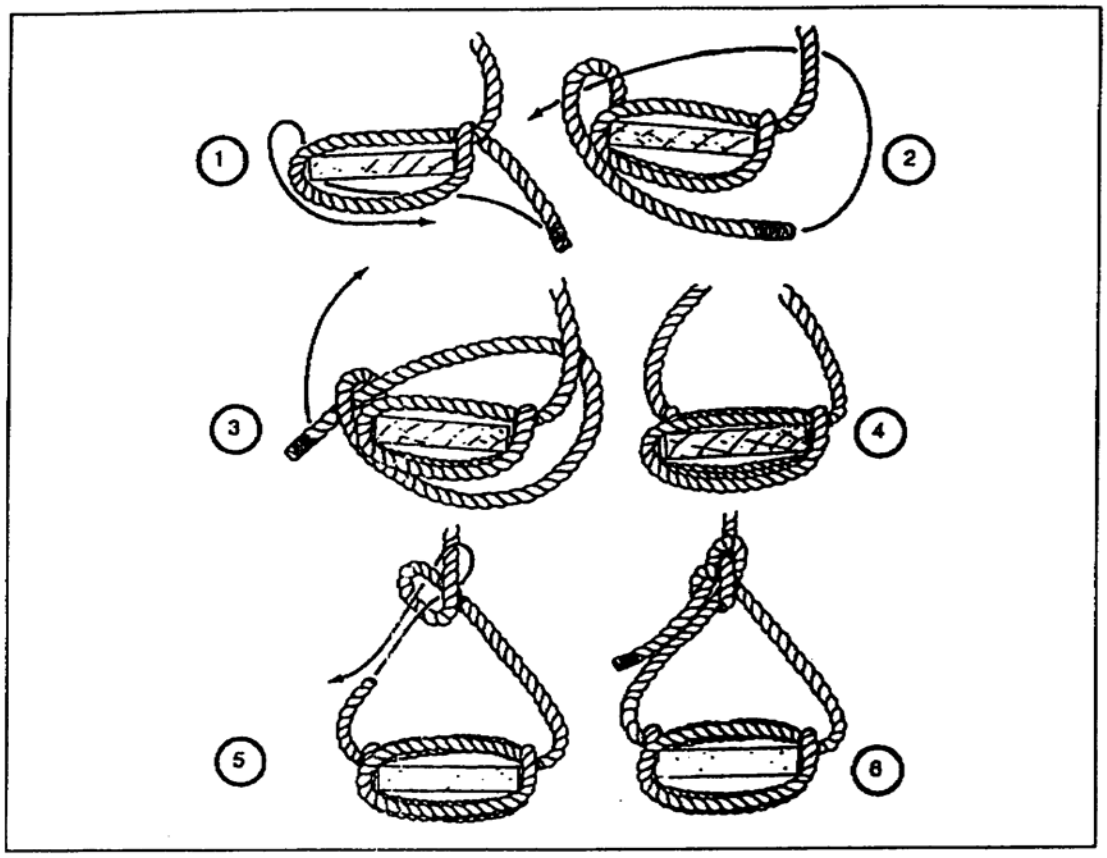

Figure 4-31. Scaffold hitch

k. Whipping. The raw, cut end of a rope has a tendency to untwist and should always be knotted or fastened in some manner to prevent this untwisting. Whipping (Figure 4-32, page 4-24) is one method of fastening the rope end to prevent untwisting. The rope is whipped by wrapping the end tightly with a small cord. This method is particularly satisfactory because there is very little increase in the size of the rope. The whipped rope end will still thread through blocks or other openings. Before cutting the rope, place two whippings on the rope 1 to 2 inches apart and make the cut between the whippings. This will prevent the cut ends from untwisting immediately after they are cut.

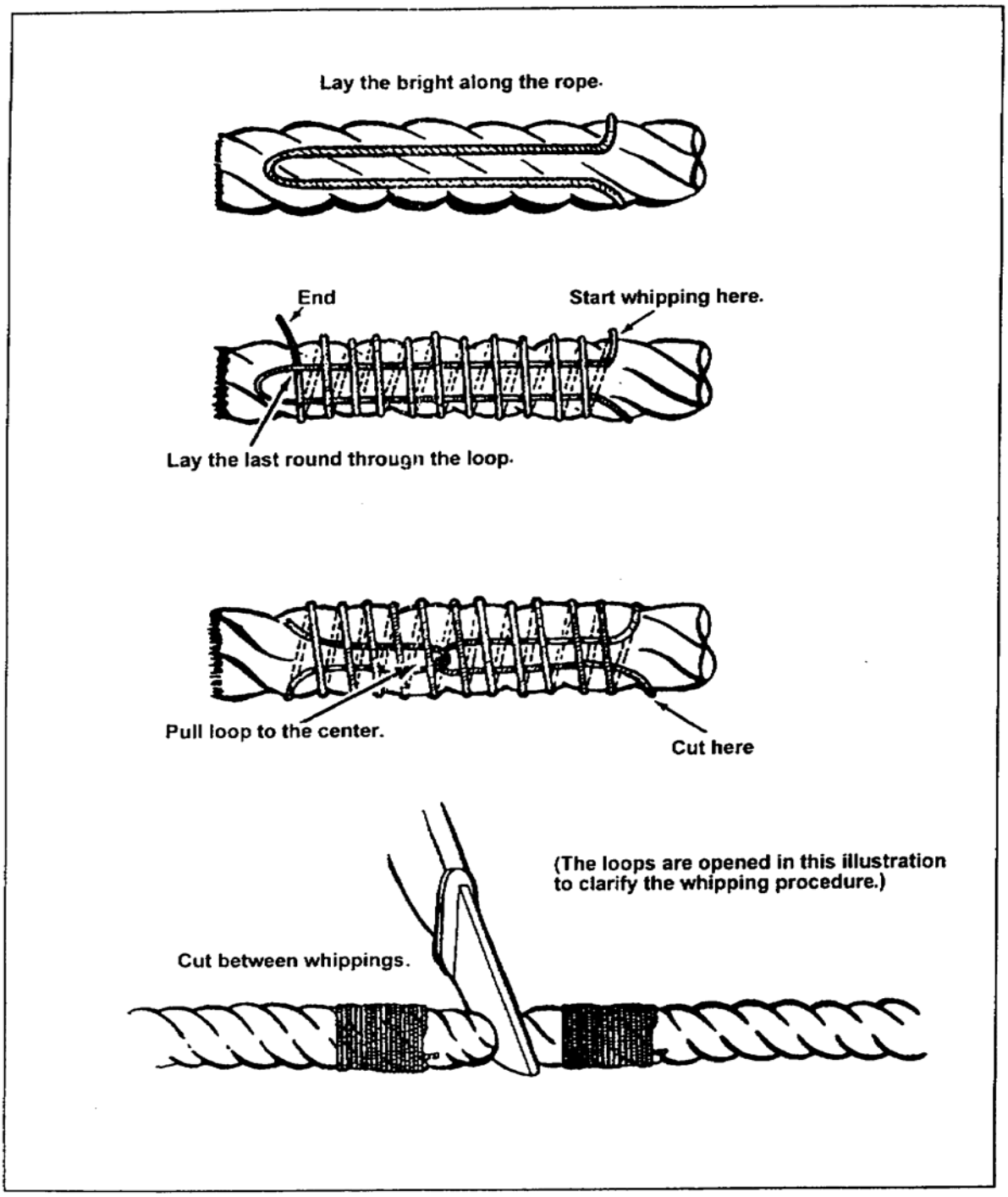

Figure 4-32. Whipping the end of a rope

Repeated tying of knots causes ropes to wear rapidly. Ropes should be inspected frequently to ensure safety. Check ropes visually for abrasions, broken fibers, cuts, fraying, or deterioration from acids or corrosive substances. Remove from service any defective ropes that are found. When not in use, store ropes in a dry, well-ventilated place.

4-4. Block and Tackle.

a. Block and tackle, also referred to as falls, are one type of hoisting equipment used to raise and lower the platform of a swing-stage scaffold. Falls are made in various combinations of single, double, and triple blocks. The number of sheaves (pulleys) used designates the size of the block. As the number of sheaves is increased, the mechanical advantage is increased. To avoid getting dirt into the operating parts of the blocks, reeve a set of blocks by laying the blocks out on a clean and level surface other than the ground. Figure 4-33 shows the reeving and threading of single and double blocks.

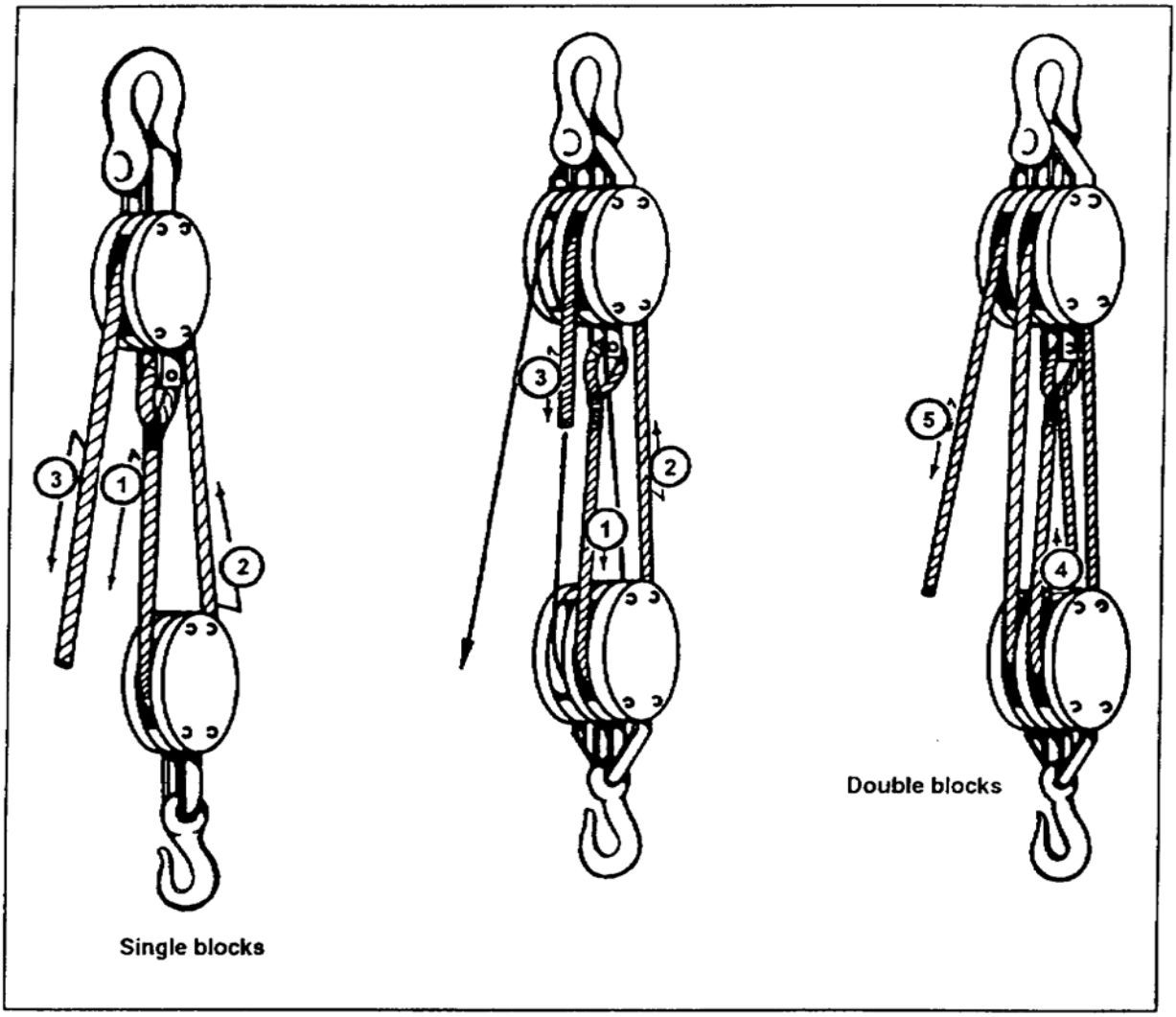

Figure 4-33. Reeving single and double blocks

b. When the reeving is completed, the blocks are ready to be fastened. Connect one block securely to the load and the other to a substantial anchor. To move the load, pull on the fall line. When you use a block and tackle for swing-stage scaffolds, the rope must be first-grade Manila that is at least 3/4-inch in diameter.

4-5. Hoisting Machine. This machine (Figure 4-34) is another item used while painting in elevated places. It uses steel cable instead of rope. The hoisting machine has a lock and a brake that are controlled by the painter. Before leaving the machine, you must remove the control handle and lock the brake. Perform daily inspections of all the ropes and cables being used to support the scaffold.

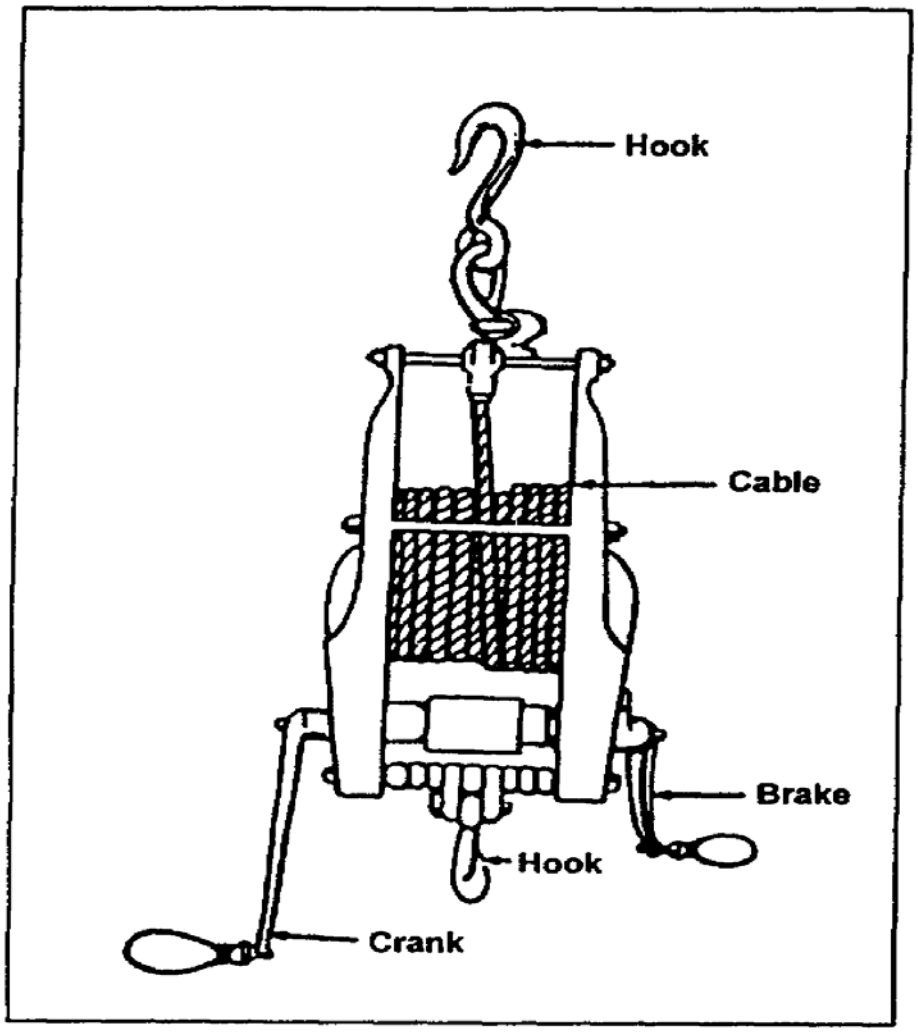

Figure 4-34. Hoisting machine

LESSON 4

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answer with the key that follows. If you answer any item incorrectly, study again that part which contains the portion involved.

1. What is the primary consideration when erecting and using ladders and scaffolds?

   A. To notify your supervisor about the assembly

   B. To follow safety procedures

   C. To install guardrails

   D. To lower the swing-stage scaffold when it is not in use

2. A hoisting machine is used to raise swing-stage scaffolds. What action do you take before leaving the hoisting machine?

   A. Raise the scaffold higher than needed and lock the break

   B. Tie yourself securely to the scaffold

   C. Remove the control handle and lock the brake

   D. Push yourself slowly away from the building

3. When a ladder is not in use, you hang it on brackets by its side rails to prevent _____.

   A. Moisture penetration

   B. Equipment loss

   C. Material warping

   D. Material splitting

4. When an erected swing-stage scaffold is not in use, it must be _____.

A. Lashed to the building

B. Lowered to the ground

C. Kept upright

D. Disassembled

5. You are placing a 24-foot ladder against a wall that you will be painting. In feet, how far from the wall do you place the bottom of the ladder?

A. 6

B. 8

C. 10

D. 12

6. You want to form a loop that will not slip and is easily untied at the end of a rope. What hitch or knot do you use?

A. Clove hitch

B. Rolling hitch

C. Half hitch

D. Bowline knot

7. To lower yourself slowly, which hitch would you use with the boatswain's chair?

A. Clove

B. Half

C. Double

D. Rolling

8. You are erecting a swing-stage scaffold on a building. How do you keep the scaffold from swinging outward after it has been hoisted?

A. By placing working weights on the outside edges of the scaffold

B. By keeping your hands on the building while hoisting the scaffold

C. By lashing the scaffold to the building

D. By equipping the scaffold with stirrup rollers

9. You are on a 15-foot ladder and you need help to complete a paint job. You tell your helper to _____.

A. Start painting from the lower side

B. Get another ladder

C. Get onto your ladder with you

D. Erect a lean-to scaffold

10. You are erecting a rolling tower that will have a base dimension of 4 square feet. What is the maximum height, in feet, of the tower?

A. 12

B. 16

C. 20

D. 24

LESSON 4

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer	
1.	B.	Safety is of prime importance in the erection and use of ladders and scaffolds. (page 4-1 introduction para)
2.	C.	The hoisting machines has a lock and brake that are controlled by the painter. Before leaving the machine, you must remove control handle and lock the brake. (page 4-26, para 4-5)
3.	C.	When ladders are not in use, store ladders in a sheltered well-ventilated place that is away from weather elements. To prevent warping, hang ladders on brackets by the ladders side rails. (page 4-8, para 4-1e)
4.	B.	Lower the scaffold to the ground when it is not in use. (page 4-14, para 4-2c[7])
5.	A.	As soon as the ladder is perpendicular, pull the ladder bottom out from the building to a distance of one-fourth the working length of the ladder. (page 4-3, para 4-la[2])
6.	D.	The bowline is used to form a single loop that will not tighten or slip under strain and can be easily untied. (page 4-18 para 4-3b)
7.	D.	The rolling hitch is used to lower a load slowly. The boatswain's chair is another important use of the hitch. You can lower yourself by releasing the pull on the fall line and rolling the knot. (page 4-22, para 4-3i)
8.	C.	Prevent the scaffold from swinging outward after hoisting by lashing it to a building or a structural wall as soon as possible. (page 4-14, para 4-2c[7])
9.	B.	Do not allow anyone on the ladder with you. If the work requires additional help, the helper should get another ladder. (page 4-8, para 4-le)
10.	B.	For safe operation, the towers height must not exceed four times its' smallest base dimension; in addition, the tower must have a guardrail above the working platform. (page 4-12, para 4-2b[3])

LESSON 5

METAL CORROSION AND IDENTIFICATION

OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn how to identify corrosion on metal, what causes corrosion, and how to prevent corrosion.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will describe the procedures for identifying the types of corrosion, what causes it, and steps to control it.

CONDITION: You will be given the material contained in this lesson.

STANDARD: You must complete the lesson and the practice exercise.

REFERENCES: The material contained in this lesson was derived from the TM 5-800 series, EM 1110-2-3400, and OPNAVINST 5100.23D.

INTRODUCTION

The corrosion of metal is a constant enemy of the military, causing extensive damage to towers, pipelines, trucks, aircraft, and almost any other item made of metal. Corrosion quietly eats away the understructure or heart of a system. The problem is never-ending. In this lesson, you will learn how to identify corrosion, find out what causes it, and learn how to control it on various types of metal.

PART A: CORROSION

5-1. Definitions. Since the corrosion of metal results in such tremendous loss of materials, time, and money, just what is corrosion? Let's consider three different definitions:

- An engineer from the Electrochemical Society of New York stated, "Corrosion is the destruction of a metal by chemical or electrochemical reaction with its environment."

- A reservoir engineer says, "Corrosion is a process of nature designed to increase the horizontal permeability of the casing."

- The Webster's Collegiate Dictionary, 10th ed, 1995, states, "The action, process, or effect of corroding." Webster further defines corroding as, "To eat away by degrees as if by gnawing."

Though the definitions vary, they all boil down to the fact that corrosion is a natural act of a metal trying to return to its lowest level of energy. In the case of a metal structure, iron and steel try to return to their natural state of iron oxide (iron ore). The so-called noble metals, such as gold and platinum, do not corrode since they are chemically uncombined in their natural state. Your concern is with the chemical changes that occur when metal is exposed to the elements.

a. Electrochemical Theory. The most common theory of corrosion is called electrochemical. An electrochemical-corrosion theory is best explained by the action that takes place in a battery cell (Figure 5-1). A galvanic battery cell is produced by placing two dissimilar metals in a suitable electrolyte that is a conducting medium in which the flow of current is accomplished by the movement of matter in the form of ions. The resulting electrochemical reaction develops a potential difference between these two metals, causing one metal to be anodic and the other metal to be cathodic. In a dry cell, the zinc case is the anode (positive terminal) and the carbon rod is the cathode (negative terminal). When an external electrical circuit is completed, current flows from the zinc case into the electrolyte, taking with it particles of zinc. This is an example of galvanic corrosion of the zinc case.

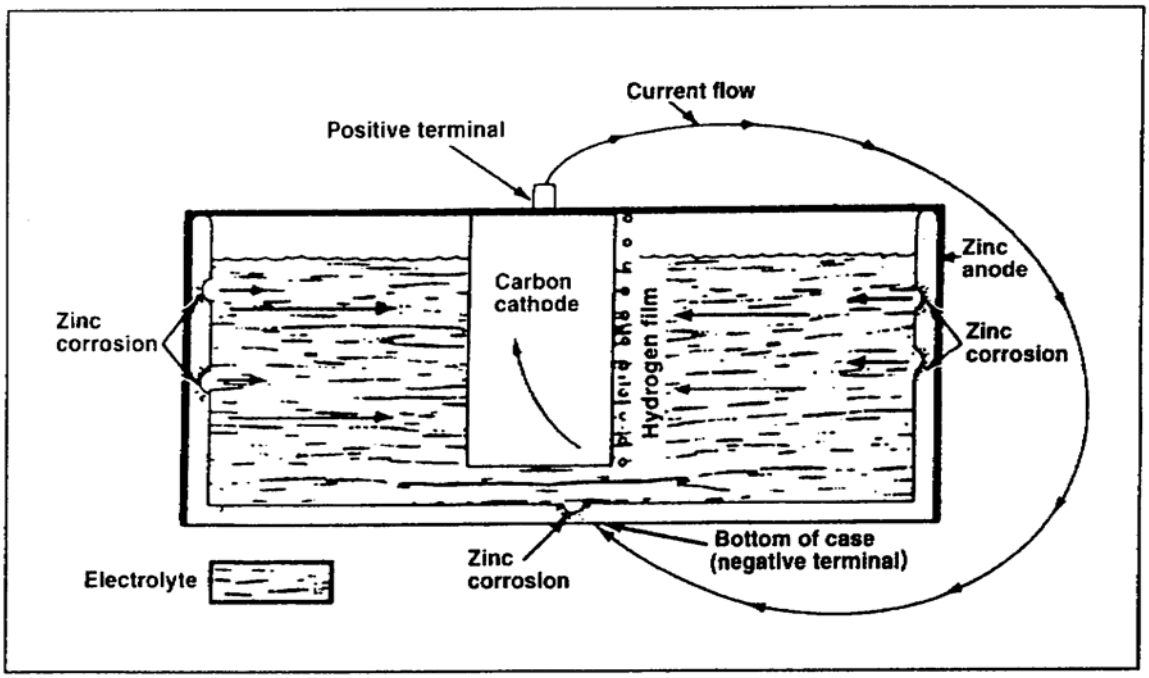

Figure 5-1. Electrochemical-corrosion theory of a battery cell

b. Electrochemical Conditions.

(1) Four conditions must exist before electrochemical corrosion can take place; namely, the presence of a metal anode, a cathode, an electrolyte, and a conductor.

- A metal anode is the device that corrodes. An anode is a positive electrode of an electrochemical cell or the level at which oxidation occurs. The electrodes leave a device to enter the external circuit. An electrode is defined as a conductor (as a metallic substance or carbon) used to establish electrical contact with a nonmetallic portion of a circuit (as in an electrolytic cell).

- A cathode is the condition that causes the corrosion. A cathode is a negative electrode of an electrochemical cell or the level at which reduction (corrosion) occurs. The electrodes enter a device from the external electrical circuit.

- An electrolyte is a nonmetallic conductor in which current is carried in a continuous liquid path (the external electrical circuit). An electrolyte provides an environment in which the corrosion process develops. The electrolyte is usually in the form of condensation and salt or other contaminants.

- A conductor is required to carry the flow of electrons from an anode (anodic area) to a cathode (cathodic area). A conductor is usually in the form of metal-to-metal contact, such as rivets, bolts, and welds.

The four conditions required for the corrosion process are shown in Figure 5-2. Elimination of any of the four conditions will automatically stop the corrosion process. For example, an organic paint film on the surface of metal will prevent an electrolyte (corrosion path) from connecting the cathodic and anodic areas and a current cannot flow; therefore, no corrosion occurs (Figure 5-3).

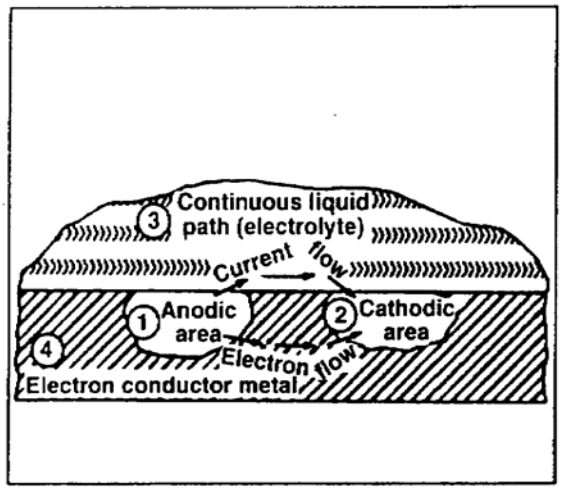

Figure 5-2. Electrochemical-corrosion condition

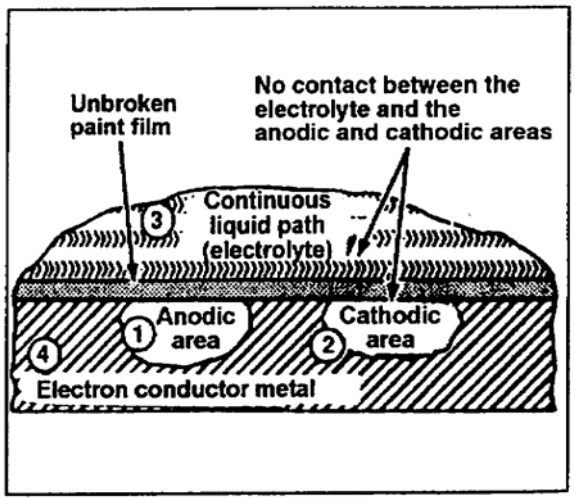

Figure 5-3. Paint film preventing corrosion

(2) The possibility of corrosion problems and the necessity for control measures will vary accordingly because some metals are more subject to corrosive action than others. A corrosive attack begins on a metal surface that is exposed to a corrosive environment. If

allowed to progress, corrosion works down into the core of the metal's material (Figure 5-4). Since corrosion never originates in the core, there will always be evidence on the surface when an attack is in progress (Figure 5-5).

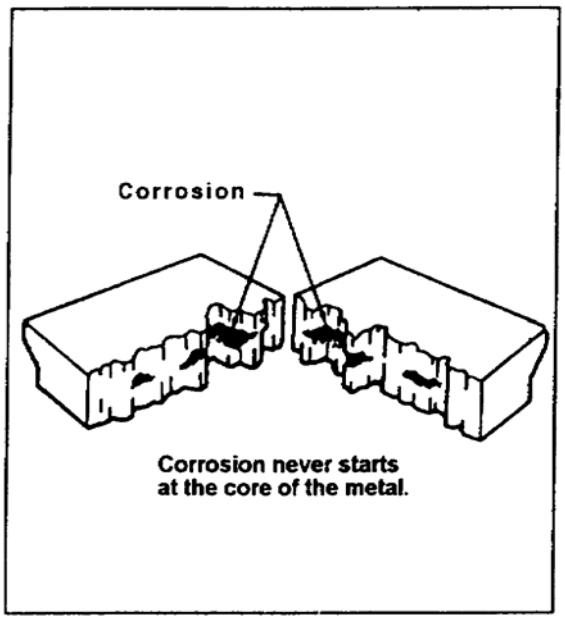

Figure 5-4. Core corrosion

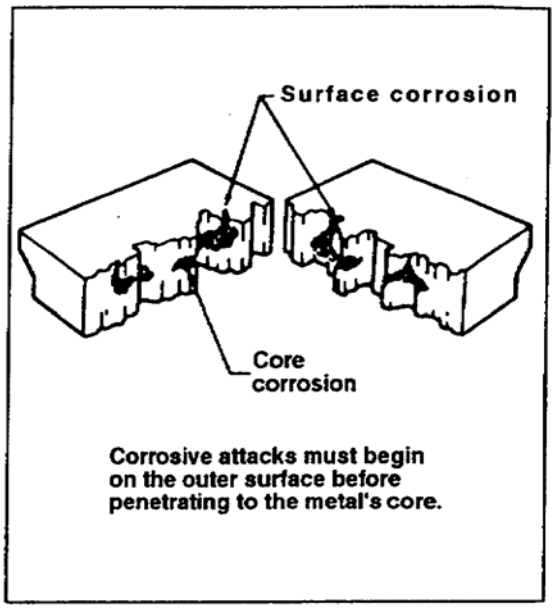

Figure 5-5. Corrosion point of entry

5-2. Forms. Before you can identify corrosion, you must know what it looks like on a metal's surface. Corrosion takes place in various forms, depending on the metal type, the environment, and the mechanical conditions. Among the many types of corrosion are the following:

a. Uniform (General). This corrosion is the most common form, which is a general attack on a metallic surface. Uniform metal etching is the surface effect produced by most direct chemical attacks. On a polished surface, this corrosion type is first seen as a dulled surface. If such corrosion is allowed to continue, the surface becomes rough and possibly frosted in appearance.

b. Galvanic.

(1) This corrosion type is a complete corrosion class that involves an electrochemical action between two metals or between different areas of the same metal having different heat treatments or other metallurgical differences. Galvanic corrosion occurs when dissimilar metals are in contact and the presence of moisture provides an external circuit (electrolyte). One recognizable feature of galvanic corrosion is the presence of corrosion buildup at a joint between metals. For example, aluminum and magnesium skins that are riveted together in an aircraft wing form a galvanic couple if moisture and contamination are present.

(2) When aluminum pieces are attached with steel fasteners or screws, galvanic corrosion (Figure 5-6) can occur between the aluminum and steel. Table 5-1, page 5-6, is a

list of metal and alloy classifications. The metals listed within each classification group have no strong tendency to produce galvanic corrosion and are relatively safe to use in contact with each other. The coupling of metals from a different group and the increased distance the groups are from each other will generally result in galvanic or accelerated corrosion of the metal higher on the list. The farther apart the metals are listed in the table, the greater a galvanic tendency will be. A galvanic tendency is determined by measuring the potential electrochemical difference between any two metals.

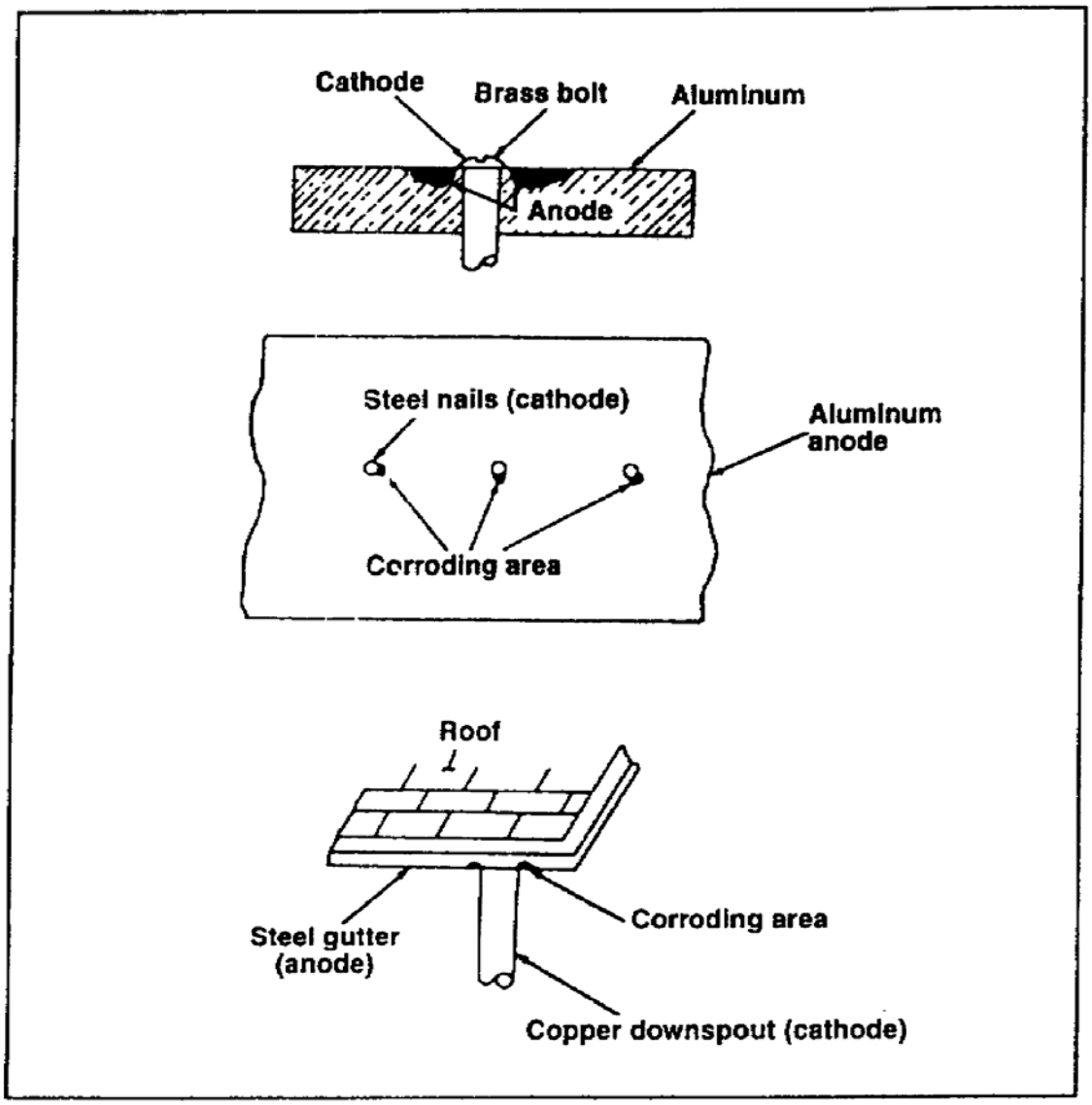

Figure 5-6. Galvanic corrosion

Table 5-1. Metal and alloy classification

Classification Groups	Metals and Alloys Found in Each Classification
I	Magnesium and its alloys
II	Cadmium, zinc, and aluminum and their alloys (including the aluminum alloys in Group I
III	Iron, lead, and tin and their alloys (except stainless steel)
IV	Copper, chromium, nickel, silver, gold, platinum, titanium, cobalt, and rhodium and their alloys; stainless steel and graphite
Metals classified in the same group are considered similar to one another. Metals classified in different groups are considered dissimilar to one another.	

(3) A metal's tendency to corrode in a galvanic cell is determined by its metal compatability position in the metal and alloy galvanic series shown in Table 5-2. The metal compatibility order listed is only appropriate for seawater at 77°F. Both temperature and the makeup of an electrolyte (water or soil) may vary the order in which the metal is listed. For example, in fresh water at a temperature above 150°F, iron may become anodic (more corrosive) with respect to zinc. The less noble (anode) the metal is, the more it suffers from an accelerated corrosion attack. The more noble (cathode) the metal is, the greater it is cathodically protected by a galvanic current. The more noble the metal or alloy, is the more chemically inert or inactive it is, especially toward oxygen.

c. Pitting. This corrosion occurs in most alloys, but it is most common in aluminum and magnesium. It is first noticeable as a white or gray powdery deposit, similar to dust, which blotches the surface. When the deposit is cleaned away, tiny pits or holes are seen in the surface. Pitting corrosion is a localized form that begins at a break in the passive (protective) film. A cell is formed between the exposed metal and the passive metal where the film is broken. Such breakdowns in the protective coating can occur at a rough spot, machining mark, scratch, or other surface flaw. Pitting corrosion can also occur under a small deposit (weld spot or dirt particle) that prevents the access of oxygen to the metal. Pitting corrosion proceeds at a rapid rate if the products of corrosion are conductive.

Table 5-2. Metal and alloy galvonic series

Corroded end (anodic or least noble)
Magnesium
Magnesium alloys
Zinc
Cadmium (galvanized steel or galvanized wrought iron)
Aluminum alloys
Steel
Wrought iron
Cast iron
Stainless steel (active)
Lead
Tin
Nickel (active)
Inconel ™ (active) (80 percent nickel, 14 percent chromium, and 6 percent iron)
Brass
Copper
Bronze
Copper-nickel alloys
Monel Metal ™ (67 percent nickel, 28 percent copper, and 5 percent other)
Nickel (passive)
Inconel (passive)
Stainless steel (passive)
Silver
Titanium
Gold
Platinum
Protected end (cathodic or most noble)

d. Stress Cracking.

(1) Stress cracking is caused by the distortion of a metal's grain structure. Distortions are induced when metals are punched, cold-riveted, shrink-fitted, or otherwise distorted after hot-finishing. Distortion is also caused by the metal bending or twisting. This bending or twisting may be a continuous stressed condition or it may be an alternating stressed and unstressed condition. Stress corrosion is due primarily to the fracture of a metal's surface, film, or coating. The corrosion process is accelerated by fractures or tiny cracks that permit moisture to enter.

(2) After surface cleaning, stress cracks are usually visible at the bottom of corrosion pits. Corrosion pits may form before or simultaneously with any stress condition. The pitting rate is more rapid with simultaneous stress. In the second stage, a stress crack at the pit base develops rapidly and gradually penetrates the section until a fracture occurs.

(3) A good example of stress corrosion is the use of cold-worked rivets to join steel sheets used in storage tank construction. The rivets carry an internal strain–the deformation of the rivet shank–that makes them anodic (dissimilar metals) to the steel. The stressed area forms the anode to the adjacent unstressed parts. Since the rivets are

very small in area compared with the steel, they become badly corroded in comparison with the action on the steel.

e. Intergranular. This corrosion is the result of the metallic grain boundaries and the grain particles creating a cell in an electrolyte, such as a corrosive solution or atmosphere. This type of corrosion is an attack on the metal's basic grain structure. A highly magnified metal cross section shows its composition is made up of a number of tiny crystals or grains. Each of these tiny grains has a clearly defined boundary, and each grain differs chemically from the one in the center of the metal. The adjacent grains of different elements react with each other as anodes and cathodes when they are in contact with an electrolyte. The early stages of this corrosion cannot be detected by normal visual inspections. Some of the stainless steels are prone to intergranular corrosion if they are heated. This is because corrosion may begin when heat from welding causes chromium carbides to collect at the grain boundaries.

f. Exfoliation. This corrosion is the visible evidence of intergranular corrosion. It shows itself by metal surface grains lifting up and lifting is caused by the force of expanding corrosion occurring at the grain boundaries just below the metal's surface. This corrosion is most often seen on rough-finished metal surfaces. The rougher, more strained, and less uniform a metal's surface, the sooner corrosion starts and the more localized the corrosion develops.

g. Concentration Cell (Differential Environmental). This corrosion occurs when several areas of a metal's surface are in contact with different concentrations of the same electrolyte. Corrosion results from a difference in the composition of the electrolyte and from the difference in the concentrations. Both conditions cause metal corrosion. An example of differential-environmental corrosion is shown in Figure 5-7.

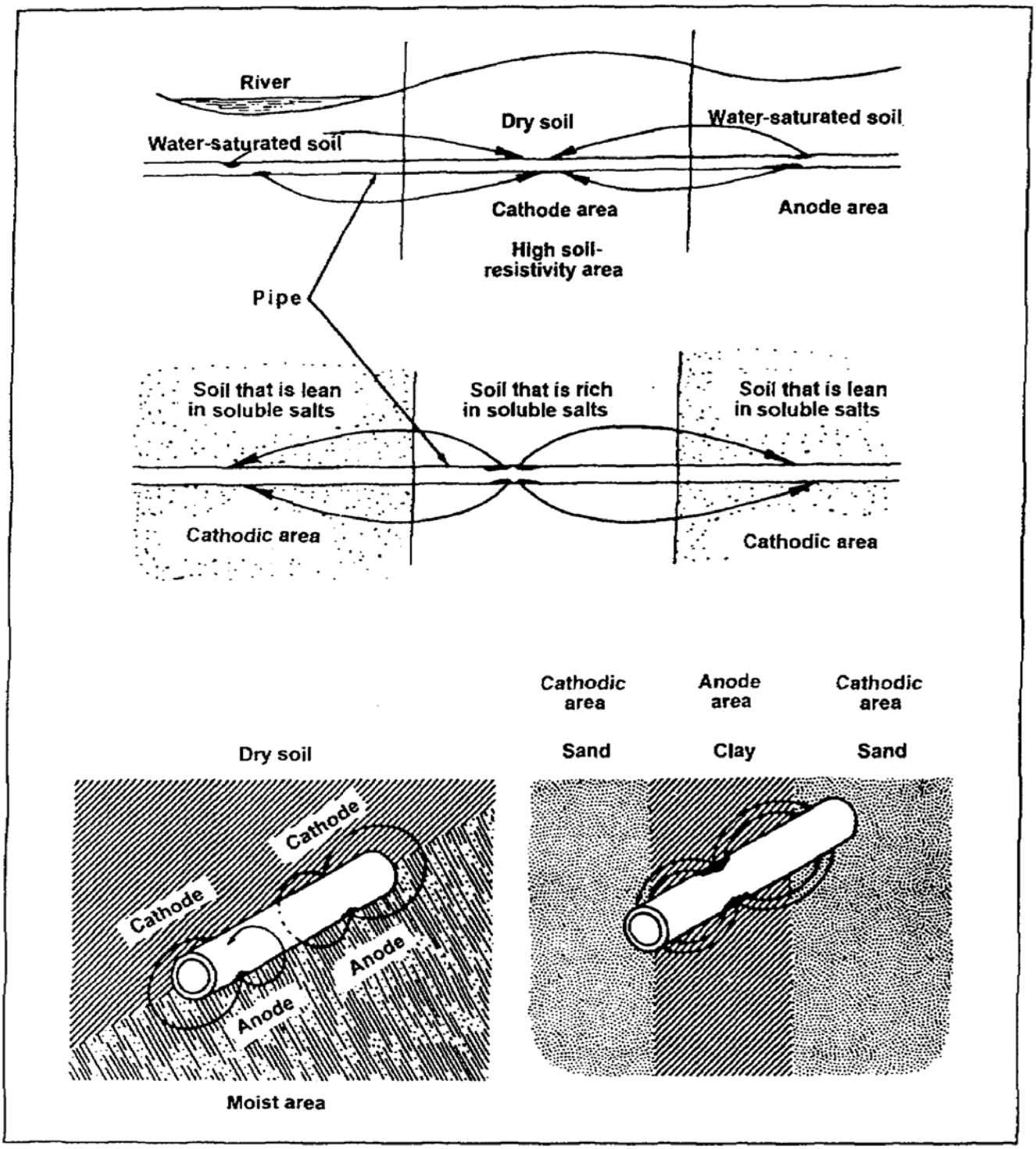

Figure 5-7. Differential-environmental corrosion

There are three types of concentration cell corrosion; they are metal-ion, oxygen, and active-passive.

(1) Metal-ion concentration cell corrosion consists of different concentrations of metallic ions in various water parts. High metal-ion concentrations will exist under the surfaces where the water is stagnant, whereas low metal-ion concentrations will exist adjacent to the crevice that is created by the raised surfaces. An electrical-potential will exist between the high- and low-concentration points. The area that has the high metal-ion concentration will be anodic and will corrode. For example, when a large object (such as a pipeline) passes through different soil environments, major corrosion cells are established and will extend over several miles. This condition results in several amperes of current flowing in the pipeline metal. Corrosion of the pipeline will occur wherever the current leaves the pipe's surface.

(2) Oxygen concentration cell corrosion occurs when a solution contains varying amounts of dissolved oxygen cells. Oxygen develops--

- At any point where the oxygen in the air is not allowed to diffuse into the solution.
- Under either metallic or nonmetallic deposits (dirt) formed on metal surfaces.
- Under fraying metal surfaces such as riveted lap joints.
- Under gaskets, wood, rubber, plastic tape, and other materials in contact with metal surfaces.
- In low oxygen-concentration areas (anode)(Figure 5-8).

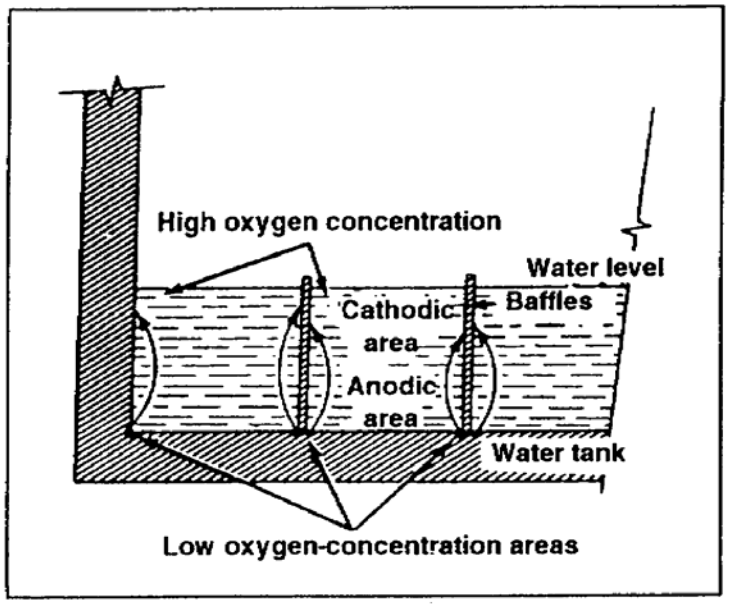

Figure 5-8. Low oxygen-concentration areas

(3) Active-passive concentration cell corrosion is commonly found on metals that depend on a tightly adhering passive film, usually an oxide, for corrosion protection. The corrosive action starts as an oxygen-concentration cell. For example, salt deposits forming on metal surfaces in the presence of water containing oxygen can create an oxygen cell. The corrosive action of the low-oxygen cells will break the passive film beneath the dirt particles, which in time will expose the active metal beneath the film to corrosion action (Figure 5-9). An electrical potential develops between the large area of the cathode (passive film) and the small area of the anode (active metal), which can produce rapid pitting of the active metal.

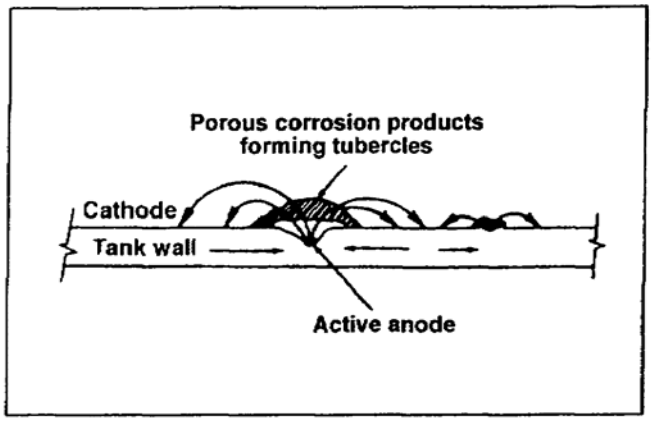

Figure 5-9. Low-oxygen cell corrosion action

5-3. Causes. The corrosive action on pipelines, structures, and equipment conveying water, petroleum, and gases is a problem of vast importance to the Army. Instead of maintaining a few feet of pipe as we do in our homes, the Army maintains thousands of feet. A substantial saving is made if the effect of corrosion on equipment is decreased. Corrosion may develop under a number of conditions, among them are mill scale, cinder, dissimilarity of pipe surface, different soil condition, stray current, bacteria, dezincification, graphitization, and hydrogen embrittlement.

a. Mill Scale. One cause of pipe corrosion is mill scale which is embedded in the walls of iron pipe during its manufacture. The component parts of this corrosion condition are the

- Cathode (cathodic area), which is the mill scale that causes the corrosion condition.
- Anode (anodic area), which is the iron pipe where the corrosion takes place.
- Conductor, which is the pipe that also serves as a metallic conductor passing currents from the anodic area to the cathodic area via an external electrical circuit.
- Electrolyte, which is the moist soil that acts as a nonmetallic conductor of current in the external electrical circuit.

The current leaves the iron-pipe wall, passes through the electrolyte soil to the mill scale, and returns to the iron pipe. This electrochemical action causes severe metal pitting at the anodic areas. Continued action of this type will eventually weaken the pipe and cause it to fail.

b. Cinder. Another type of corrosion occurs when iron pipe is laid in a cinder fill and is in direct contact with the cinders. The component parts of cinder corrosion are the-

- Dissimilar metals, which are the cinders and the iron pipe that also serve as conductors.
- Anode, which is the iron-pipe wall where the corrosion takes place.
- Cathode, which is the cinders that cause the corrosion.
- Electrolyte, which is the highly ionized soil that serves as the external electrical circuit or environment for the corrosion process.

The current leaves the pipe through the soil to the cinders and returns to the pipe. Severe corrosion occurs at the points where the current leaves the pipe. Galvanic corrosion wears away the pipe at an accelerated rate because of the nonpolarizing effect of the cinders and the highly ionized soil contamination of the cinders.

c. Dissimilarity of Pipe Surface. This galvanic corrosion occurs when there are bright or polished surfaces on some areas of iron-pipe walls, and the dissimilar pipe surfaces are in contact with suitable electrolytic soil. A pipe wrench can produce bright surfaces, such as scars and scratches, on the pipe when assembling it. The threads on both ends of a coupling may expose polished surfaces that corrode easily. Corrosion in the threads will eventually cause the perforation of the iron-pipe wall.

d. Different Soil Condition. This is a general corrosion problem that is especially prevalent in high-alkaline areas. Corrosion currents enter or pass through an iron-pipe wall from compact soils. Corrosion currents also enter or pass through the iron-pipe wall from light sandy soils. The intensity of the corrosion currents and the resulting corrosion rate at the pipe's anodic areas are directly proportional to the soil's conductivity. Earth current meters are used to determine the location of the anodic and cathodic areas and the extent to which a corrosion current exists. This meter determines if the pipe requires protection.

e. Stray Current. Stray currents, many of which are direct causes of corrosion, are usually direct-current circuits that pass in and out of an electrolyte. This condition poses the greatest problem in the vicinity of electrical-transportation systems, electrified coal mines, or manufacturing plants where the direct-current distribution system requires a ground as a complete or partial circuit return. If a metallic structure, such as a tank or pipeline, is laid in such an area, a large galvanic cell is created, making a perfect setup for corrosion. Corrosion does not occur at the point where the current enters the structure because it is cathodically protected. However, at the section where the current leaves the

structure, severe, stray-current corrosion occurs. Over a period of a year, this type of corrosion is known to displace as much as 20 pounds of iron-pipe wall for every ampere of current.

f. Bacteria.

(1) Another distinct corrosion that results from the electrolytic or galvanic cell action of minute organisms is bacteria (microbiological corrosion). Microbiological corrosive action is the deterioration of metal by a corrosion process that occurs as either a direct or indirect result of the activity of certain bacteria, particularly in water or soil environments. Organisms that cause microbiological corrosion are bacteria, slime, and fungi.

(2) The microbiological corrosive action that occurs in the soil is due to the physical and chemical changes in soil by the action of bacterial-type organisms. Some bacterial-type organisms are responsible for the production of active galvanic cells. These cells are produced by variations of the oxygen content in the soil (differential aeration) or by the reduction of the hydrogen film over the cathodic areas (depolarization). Bacterial-type organisms are mostly found in highly water-logged, sulfate-bearing, blue-clay soils. The bacterial concentration as well as the corrosion rate varies considerably with the different seasons of the year. Cast iron and steel pipe are corroded mostly by the sulfides produced by the bacteria.

g. Dezincification. Dezincification is a selective corrosion that occurs in copper and zinc alloys. When alloys of this kind (brasses) are exposed to dezincification corrosion, the zinc will dissolve out of the alloy, leaving only copper. Since most pipe fittings are made of brass, dezincification attacks and weakens these brass fittings to the point of failure. In this case, the zinc ions go into solution, leaving the copper. The solution may be impure water or oil that acts as an electrolyte.

h. Graphitization. Graphitization, or graphite softening, is a peculiar disintegration form that attacks gray cast iron. Cast iron is an alloy made of iron and carbon, the carbon being in the form of graphite. When cast iron with such a composition is subjected to graphitization, the graphite pipe may last for many years if it is not subjected to any mechanical forces or sudden pressures.

i. Hydrogen Embrittlement. Hydrogen embrittlement is a term applied to metal that becomes brittle due to hydrogen action on its surface. When hydrogen forms on the surface of steel, the hydrogen action may form blisters or actually embrittle the metal. It has been demonstrated that hydrogen, which is liberated near the surface of steel in an electrolyte environment, will diffuse into the metal quite rapidly. This hydrogen, picked up by the steel in an atomic state, causes the steel to become brittle. When atomic hydrogen production on the metal's surface stops, the hydrogen leaves the metal in a few days and the metal again regains its original ductility. Carbon steels have shown that they are affected by hydrogen embrittlement according to the hardness in the steel. The harder the metal, the greater the susceptibility to hydrogen embrittlement. Hydrogen embrittlement in carbon steel is also increased by the presence of stress.

5-4. Controls. Now that you know what corrosion is and what causes it, you must know how to control it. Basically, the same principle that causes corrosion is used to counteract it. This is done in several ways, but the most common are known as passivation and cathodic protection.

a. Passivation.

(1) A passivator is an inhibitor that changes the potential of a metal to a more cathodic value. An inhibitor is a chemical substance or mixture which, when added to an environment, usually in small concentration, effectively decreases corrosion. Table 5-3 lists several mixture types for passivating metal surfaces. The term passivity may be defined as the property by which certain metals become inactive in a specific environment. Metals that do not form protective films under service conditions are protected by the method of immersion in a chemical bath containing inhibitors. The passivity of a metal, such as stainless steel, is gained by the method of a protective-film formation (electroplate) on the metal's surface through its absorption of atoms or ions.

(2) By either of the methods (immersion or protective film), the passivation of the metal's surface serves to make the surface more resistant to corrosion by either physical or chemical treatment. One is based on the corrosive behavior of the metal or alloy, and the other is based on the electrochemical behavior of the metal or alloy.

Table 5-3. Mixtures for passivating metal surfaces

Coating Type	Metal	Mixture	Application Method
Zinc	Iron, steel	5 to 10 percent hydrochloric acid/water solution for 5 to 15 seconds (76°F)	Dip or brush
Cadmium	Tin	Same as above (except 68 to 77°F)	Dip or brush
Tin	Iron, steel	4 ounces concentrated sulfuric acid 0.4 ounce tartaric acid 0.4 to 8 ounces animal glue 0.13 ounce beta-naphthol for each gallon of water in tank (68 to 77°F) Apply 10 to 30 amperes per square foot.	Immerse until desired thickness is obtained
Chromic-nitric-hydrofluoric acid pickle	Used for pickling all types of castings to passivate the surface before machining	37.5 ± 2.5 ounces chromic acid 3 ± 0.5 fluid ounces nitric acid 1 ± 0.2 fluid ounces hydrofluoric acid for each gallon of water in tank (70 to 90°F)	Immerse from 30 seconds to 2 minutes
Electroplate	Stainless steel	1 part sulfuric acid in 4 parts water Apply 200 amperes per square foot.	Immerse
Manganese	Ferrous metals, (used to pickle parts that will go into long-term storage or as a base for paint)	55 pounds liquid manganese 33 pounds liquid zinc phosphate 20 pounds degreased steel wool per 100 gallons of water (205 to 210°F)	Immerse 45 minutes (shake frequently)
Nickel	Brass/copper Steel/aluminum	44 ounces nickel sulfate 5 ounces nickel chloride 5 ounces boric acid per gallon of water in tank Apply 20 to 100 amperes per square foot.	Immerse

(3) A metal's passivity is attributed, directly or indirectly, to a protective film that changes the metal's or alloy's galvanic potential in a more noble direction. For example, the inhibiting action of the chromate ion in zinc chromate priming paint provides protection by passivation or mechanical means. The zinc chromate diffused in the paint provides a concentration of chromate ions on the metal's surface and tends to passivate the base metal. The chromate film shares electrons from surface iron atoms to make the metal surface less reactive and more noble in the galvanic series (Table 5-2, page 5-7). Sodium nitrate is also used as a passivator and will render iron several tenths of a volt more noble than iron in distilled water. The nitrate ion is oxidizing in nature and, like chromates and other oxidizing passivators, reduces corrosion.

(4) The use of metallic coatings and claddings is another way of making a metal passive to its environment. This means of metal protecting plates a metal's surface with another corrosion-resistant metal. In some cases, plating gives the base metal a hard, wear-resistant surface in addition to providing protection against corrosion.

(5) The application of anodic coating to magnesium and zinc protects them against corrosion. The protective oxide film that is provided by an anodic treatment is of the same general type as that afforded by a natural oxide film. The natural film is very thin; thus, anodic coating, because of its greater thickness, uniformity, and abrasion-resistance, offers better protection against corrosion. Look again at Table 5-3, page 5-15, and study the passivation types that are applicable to different metals as well as the chemicals used for passivation.

(6) Passivation by the electron theory deals specifically with metals and alloys that become more noble because of their electrochemical behavior. In application, advantage is taken of the corrosion-inhibiting action of ions in protective coatings that passivate by both electrochemical and mechanical means. Coatings and claddings are also used and frequently provide the most economical solution to corrosion problems.

b. Cathodic Protection. Cathodic protection is a method used to protect metal structures from corrosive action. As explained before, galvanic cell corrosion is the major contributing factor to the deterioration of metal by an electrochemical reaction. The area of a structure that corrodes is the anode or positive electrical current that leaves the metal and enters the electrolyte. Galvanic cathodic protection is designed to stop this positive current flow. When the current is stopped, the corrosive action stops and the anodes disappear. This type of protection depends upon the neutralization of the corroding current and the polarization of the cathodic metal areas. Galvanic cathodic protection is a procedure for reducing or preventing metal surface corrosion by using sacrificial anodes or impressed current methods. The sacrificial anode method is known as the galvanic anode method. The impressed current method is the galvanic cathodic method; however, it is referred to as the impressed current method. Depending on the corrosive characteristics of the electrolyte surrounding the structure, galvanic anode and impressed current methods are used separately or in conjunction with each other.

(1) Galvanic anode method. This cathodic protection method uses an electrode that is referred to as a sacrificial anode which corrodes to protect a structure. This sacrificial anode is electrically connected to, and placed in, the same electrolytic area of the structure. To protect iron or steel structures, use a sacrificial anode made of magnesium or zinc so that it will produce a sufficient potential difference to cause the structure to become a cathode. The action of this galvanic protection causes the electrical current to flow from the sacrificial anode through the electrolyte to the structure to be protected. The electrical connection between the two metals completes the circuit and allows current to return to the corroding metal. The sacrificial anode becomes the anode of the established, dissimilar metal galvanic cell; the structure to be protected becomes the cathode. The current from a sacrificial anode is intense enough to oppose or prevent all positive current flows from leaving the anodes in the structure to be protected. The prevention of the positive current flow from the anodic areas in the structure reduces the corrosion rate to almost zero. Galvanic cathodic protection is used in areas where the corrosion rate is low and electric power is not readily available. The gas-fired, hot-water tank and the buried oil tank, shown in Figure 5-10, are typical examples of galvanic cathodic protection.

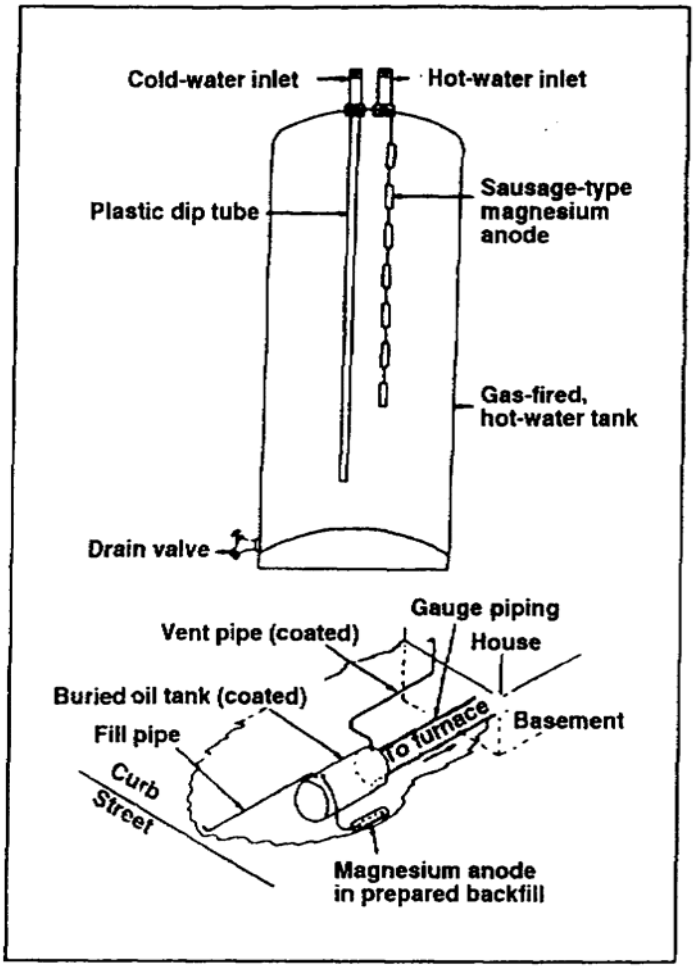

Figure 5-10. Galvanic cathodic protection

(2) Impressed current method. The impressed current method of cathodic protection is designed to protect large metal structures that are located in corrosive areas. An alternating current source is required with this protection method. In addition, a rectifier is necessary to obtain the required direct-current potential. The basic principal of the impressed current method is merely the application of the galvanic-celled reaction. The component parts of this method are the-

- Cathode (cathodic area), which is the metal structure to be protected.
- Anode (anodic area), which is composed of suitable anodic material.
- Electrolyte (or ground), which is the ionized corrosive material.
- Rectifier and various connections, which complete the electrical current.

The operation of this method depends on a rectifier that forces direct electrical current from the anode through the electrolyte to the metal structure that needs protection. This method causes the metal structure to be the cathode, suppresses all anodic currents from

it, and prevents corrosion of the structure. Figure 5-11 shows a setup of an impressed current method of cathodic protection.

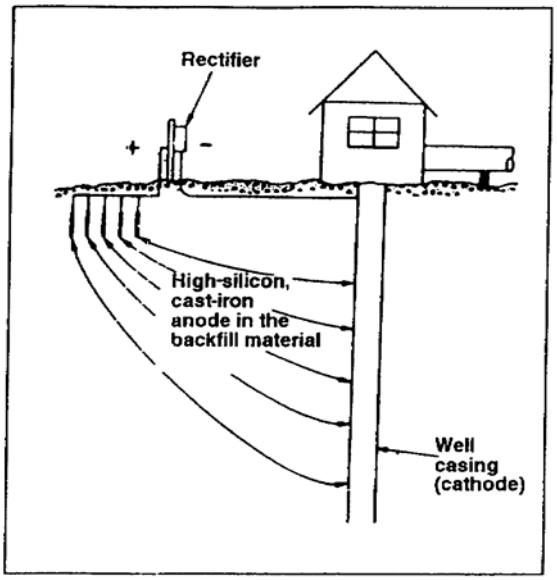

Figure 5-11. Impressed current method of cathodic protection

PART B: METAL IDENTIFICATION

5-5. Metal-Identification Tests. Unknowingly, you identify metal everyday; for instance, a penny is made of copper, dimes and quarters are made basically of silver, and nickels are made of nickel. You can identify them by looking at them. Some metals are identified by their use, such as aluminum for aircraft skin, and copper for electrical wire. However, this general classification is not good enough for the purpose of corrosion control, because if you misidentify a metal type, the work you do may damage the metal or create a condition that will increase the possibility of corrosion. By misidentifying metal, you may waste your efforts, damage material, or cause corrosion. The first and most important step in fighting corrosion is identifying the material that is being attacked or will require protection from attack. There are other tests besides general classification that will help you determine what type of metal you are working with, such as visual examinations and mechanical, chemical, and complex tests.

a. Visual Examination. This examination reveals numbers or color codes that will identify a metal. The Society of Automotive Engineers (SAE) and the American Iron and Steel Institute (AISI) have established a means of identifying steels with numbers and colors.

(1) Number system. The number system, which is a steel identification numerical index (Table 5-4), works in the following manner. A four- or five-digit number is used to indicate the steel type. For example, 2330 is a number code identifying a certain

steel. The first digit, 2, indicates the main alloy element; in this case, nickel. The second digit, 3, indicates the percentage of the main alloy element other than carbon; thus, there is 3 percent nickel. The last two digits in the number indicate the amount of carbon expressed in hundredths of percent; the example indicates that the steel has 0.30 percent carbon. In the case of a five-digit number, the second and third digits are used to express the percent of the main alloy element when this figure requires more than one digit; for example, 1.50 percent and 18.00 percent. In the case of plain carbon steel, 1095, the same system of interpreting numbers is used except that the digit 1 represents carbon steel, and since there is no main alloy element other than carbon, the second digit is always 0.

Table 5-4. Steel identification numerical index

Steel Type	Number Code
Carbon steels	1XXX
Plain carbon	10XX
Free-cutting steels (screw stock)	11XX
Manganese steels	13XX
Nickel steels	2XXX
0.50 percent nickel	20XX
1.50 percent nickel	21XX
3.50 percent nickel	23XX
5.00 percent nickel	25XX
Nickel-chromium steels	3XXX
1.25 percent nickel, 0.60 percent chromium	31XX
1.75 percent nickel, 1.50 percent chromium	32XX
3.50 percent nickel, 1.50 percent chromium	33XX
3.00 percent nickel, 0.80 percent chromium	34XX
Corrosion and heat resisting	30XXX
Molybdenum steels	4XXX
Chromium-molybdenum	41XX
Chromium-nickel-molybdenum	43XX
Nickel-molybdenum	46XX and 48XX
Chromium steels	5XXX
Low chromium (0.60 to 1.10 percent)	51XX
Medium chromium (1.20 to 1.50 percent)	52XXX
Corrosion and heat-resistant	51XXX
Chromium-vanadium steels	6XXX
Tungsten steels	7XXX and 7XXXX
Chrome-nickel-molybdenum steels	8XXXX
Silicon-maganese steels	9XXX

NOTE: The sulfur content of these steels is higher than that normally found in plain carbon steels. These are fast-cutting steels commonly used for screw stock.

(2) Color-code system. This system is linked to the numerical system of identifying the various alloys and is used to mark them. At present, there are two color-code systems in use for identifying metals and alloys. The old SAE-AISI system is related primarily to steel metals; however, the new system changes the old system and adds aluminum and copper alloys.

The new system uses an identification-marking and code (Table 5-5) and has its own color-code breakdown. For each number used (1, 2, 3, 4, 5, 6, 7, 8, 9, and 0), there is a designated color (column 1). The numbers are listed in column 2, and the letters (F, H, O, T, W, A, B, C, D, and S) are listed in column 3. For example, blue is designated as the number 1 and the letter F.

Table 5-5. Identification marking and color code breakdown

Color Identification Number		Column 1	Column 2	Column 3
Federal Standard Number 595		Color	Number	Letter
1520	501	Blue	1	F
1460	503	Green	2	H
1405	504	Olive drab	3	O
1310	506	Yellow	4	T
1205	508	Orange	5	W
1105	509	Red	6	A
1010	510	Maroon	7	B
1755	511	White	8	C
1645	512	Gray	9	D
1770	622	Black	0	S

A combination of these colors, which represents a combination of numbers and letters, is used to mark the material to denote its general composition or condition, where applicable. In the example shown in Figure 5-12, the aluminum tubing's identification markings for the base-metal color codes are green, black, green, and orange; and for the temper- and strain-handening color codes are yellow and red. By comparing these colors with the adjacent numbers and letters in columns 2 and 3 of Table 5-5, above, you can identify this metal as 20-25-T6.

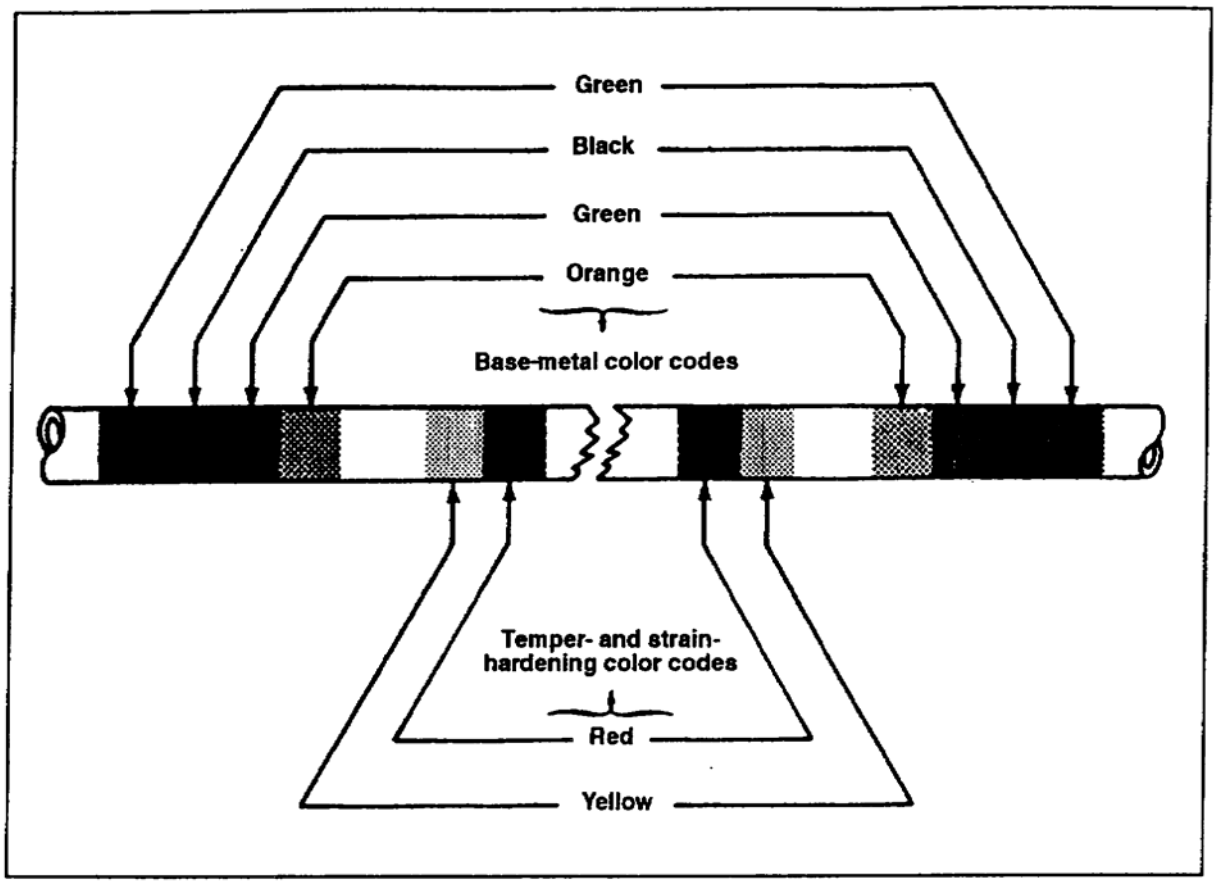

Figure 5-12. Identification markings

(3) Markings. A further test for identifying metals is to check for markings such as the manufacturer's part or specification numbers. Check such data against part numbers or the group numbers shown in the TO 00-25-113 series, or the alloy group and material specifications.

(4) Common use. When a specimen cannot be identified by part or specification numbers, examine its physical appearance and determine its possible common use. Check the color of the metal. Is the color silver, like polished aluminum or magnesium; yellow, like brass or gold; gray, like zinc or lead? The metal color may indicate which alloys and elements are present.

b. Mechanical Testing. If a metal cannot be positively identified by visual examination, see if it is attracted by a magnet. Perform a spark test if the metal is magnetic.

(1) Magnetic testing. To determine whether the specimen is attracted by a magnet, the magnet should be free-swinging from a chain, ring, or string. Metals commonly attracted by a magnet are iron, steel, or iron-based alloys containing nickel, cobalt, or chromium. However, there are exceptions to this general rule. This test can serve only as an initial step in identifying a specimen and never as a final test. Strong-magnetic metals include pure iron, nickel, and cobalt; iron-nickel-cobalt alloys; and alnico

which consists of aluminum, nickel, and cobalt. Light-magnetic alloys include stainless steel and Monel Metal (nickel and copper). All other metals and alloys are nonmagnetic.

(2) Spark testing. This test identifies some metals by characteristic sparks that are thrown off when the specimen is held against a high-speed grinding wheel. The spark streams may vary from a few tiny sparks to a shower of sparks. Skill in spark testing takes practice. When possible, compare the sparks thrown off by the unknown specimen with spark streams from known samples. Standard samples of known specifications should be maintained for comparison purposes. When testing, hold the specimen with a firm, even pressure against the top of the grinding wheel. To free a wheel of metal particles retained during previous uses, clean the grinding wheel surface frequently.

(3) A high-speed bench grinder is recommended for spark testing. Use a 6- to 8-inch wheel, medium-grit composition, 1/2 to 3/4 horsepower, 110 or 220 volts, and 3,400 to 4,000 revolutions per minute. Always wear goggles when spark testing. Metals and alloys that produce a spark on the grinder include aluminum, brass, cadmium, copper, gold, lead, zinc, and antimony. Stainless steels and high-temperature alloys with iron- and nickel-based compositions will produce characteristic sparks (Figure 5-13). As a general rule, the more iron in a specimen, the lighter the spark. As the percent of iron decreases and the percent of nickel increases, the spark will darken.

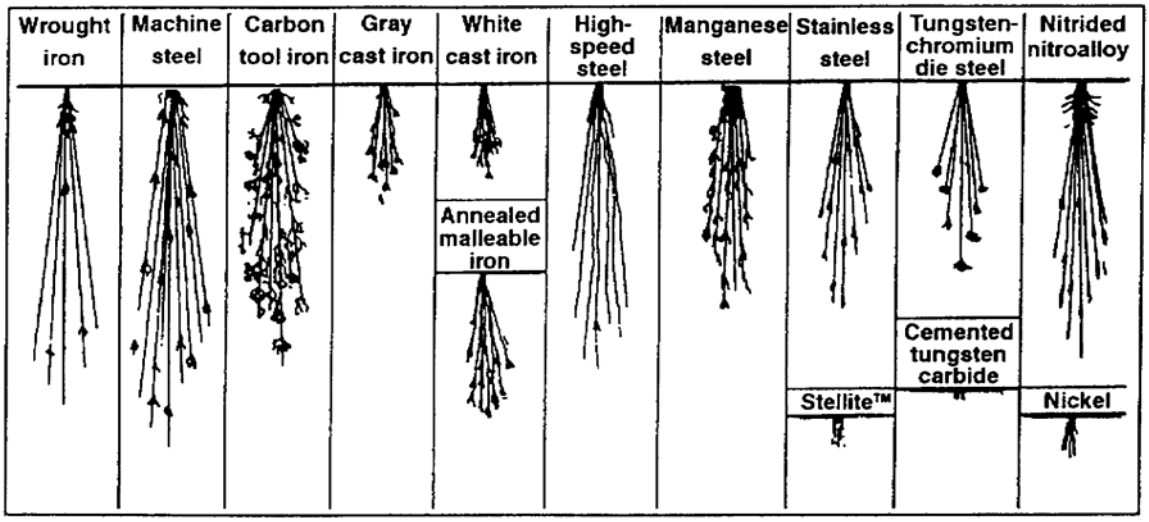

Figure 5-13. Typical spark streams

c. Chemical (Acid) Spot Testing. When metals cannot be identified by visual examination or mechanical testing use an acid spot test. Acid spot testing is done by placing one or more drops of acid on the metal surface of a specimen, observing the surface's reaction to the acid, and comparing the color reaction to a specific table of acid spot-test reactions. Clean a small surface of the metal with an emery cloth, file, or grinding wheel before spot testing. Some of the acids needed for testing are-

- Nitric acid (concentrated).
- Hydrochloric acid (concentrated).

Potassium ferricyanide (10 percent solution--dissolve 10 grams of potassium ferricyanide in 100 milliliters of water).

(1) Nitric-acid testing. There are two forms of nitric-acid testing; they are concentrated and diluted.

(a) For concentrated nitric-acid testing, place one drop of concentrated nitric acid on a clean metal surface. Table 5-6 shows the possible test reactions.

(b) For diluted nitric-acid testing, place one drop of diluted nitric acid (50 percent acid and 50 percent water) on a clean metal surface. Table 5-7 shows the possible test reactions.

(c) Aluminum, antimony, cobalt, gold, high-temperature alloys, tungsten, lead, platinum, stainless steels, tantalum, and titanium do not react to nitric-acid (concentrated or diluted) testing.

Table 5-6. Concentrated nitric-acid test reactions

Metal	Possible Color Reactions
Brass	Blue-green
Cadmium	Yellow
Cobalt (pure)	Red
Copper	Blue-green
Copper-nickel	Blue-green
Magnesium	Effervescent—no color reaction
Monel Metal	Green
Nickel (pure)	Pale green
Silver	Gray-white
Tin	White
Zinc	Effervescent—black (brown fumes)

Table 5-7. Diluted nitric-acid test reactions

Metal	Possible Color Reactions
Iron	Brown-black
Manganese steel	Brown
Nickel-iron alloy (5 to 80 percent nickel—balance iron)	Brown

(2) Hydrochloric-acid testing. Aqua regia (nitrohydrochloric) acid consists of one part nitric acid mixed with three parts of hydrochloric acid. Since this mixture breaks down after 24 hours, perform the test by placing one drop of nitric acid and three drops of hydrochloric acid directly on the spot being tested. This solution should turn blue-green for cobalt-based alloys and green for nickel-based alloys.

(3) Potassium-ferricyanide testing. Use potassium ferricyanide (10 percent solution) to determine the iron content of nickel-based alloys since there is no simple spot-testing for determining the percent of nickel content. Perform this test by adding a drop of potassium ferricyanide to the spot tested by aqua regia. The color reaction will be very dark blue-black for high iron content and light blue for low iron content.

d. Complex Testing. Complex tests are qualitative tests consisting of a spectrographic or chemical analysis. Use them only when a specimen cannot be identified by other tests or when the quantity involved warrants it.

LESSON 5

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answer with the key that follows. If you answer any item incorrectly, study again that part which contains the portion involved.

1. Metals that cannot be identified by visual examination or mechanical testing might be identified through the use of a/an _____.

   A. Magnet

   B. Color number

   C. Grinder

   D. Acid spot test

2. Where or when does metal corrosion begin?

   A. During milling

   B. On exposed surfaces

   C. Before coagulation

   D. In the metal core

3. To protect a structure's surface, a sacrificial anode is applied. What corrosion-protection method is being used?

   A. Concentration cell

   B. Differential

   C. Galvanic anode

   D. Impressed current

4. Two years ago, a storage tank was constructed using cold rivets to join the steel sheets. Your present inspection shows corrosion in the joined parts. What type of corrosion has formed in the joined parts?

A. Exfoliation

B. Galvanic

C. Intergranular

D. Stress

5. The impressed current method of cathodic protection preventsa metal structure corrosion by

A. Using a source of alternating current

B. Using a stronger electrolyte

C. Preventing galvanic corrosion of the soil

D. Balancing the electrical potential of the metal

6. Which four conditions must be present before electrochemical corrosion occurs?

A. An electrolyte, a conductor, a cathode, and a metal anode

B. A cathode, a metal anode, an electrolyte, and an organic film

C. A metal anode, a conductor, an organic film, and a cathode

D. An organic film, a metal anode, a cathode, and an electrolyte

7. Which of the following could produce a condition leading to corrosion?

A. The reduction of a voltage rectifier

B. The viscosity of a print

C. The passivation process

D. The misidentification of a metal

8. If you cannot positively identify a metal by visual identification, it should be _____.

   A. Tested for unusual stress

   B. Given magnet and spark testing

   C. Treated as steel

   D. Given ring testing

9. Corrosion presents a greater problem when it occurs in the vicinity of a/an _____.

   A. School building housing wood-working equipment

   B. Manufacturing plant with 100 automotive vehicles

   C. Electrified coal mine

   D. Office building lighted by fluorescent lighting

10. A pipeline is buried in cinders, corrosion will occur when the current _____.

   A. Accumulates on the pipe's interior

   B. Equalizes

   C. Leaves the pipe

   D. Enters the pipe

LESSON 5

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer	
1.	D.	When metals cannot be identified by visual examination or mechanical testing use an acid spot test. (page 5-22, para 5-5c)
2.	B.	A Corrosive attack begin on a metal surface that is exposed to a corrosive environment. If allowed to progress, corrosion works down into the core of the metal's material. Since corrosion never originates in the core, there will always be evidence on the surface when an attack is in progress. (pages 5-3 and 5-4, para 5-lb[2])
3.	C.	The cathodic protection method uses an electrode that is referred to as a sacrificial anode which corrodes to protect a structure. (page 5-16, para 5-4b[1])
4.	D.	A good example of stress corrosion is the use of cold-worked rivets to join steel sheets used in storage tank construction. (page 5-7, para 5-2d[3])
5.	A.	An alternating current source is required with this protection method. In addition, a rectifier is necessary to obtain the required direct-current potential. (page 5-17, para 5-4b[21
6.	A.	Four conditions must exist before electrochemical corrosion can take place; namely, the presence of a metal anode, a cathode, an electrolyte, and a conductor. (page 5-3, para 5-1b[(1])
7.	D.	By misidentifying metal, you may waste your efforts, damage material, or cause corrosion. (page 5-18, para 5-5)
8.	B.	If a metal cannot be positively identified by visual examination, see if it is attracted by a magnet. Perform a spark test if the metal is magnetic. (page 5-21, para 5-5b)
9.	C.	Stray currents, many of which are direct causes of corrosion, are usually direct-current circuits that pass in and out of an electrolyte. This condition poses the greatest problem in the vicinity of electrical-transportation systems, electrified coal mines, or manufacturing plants where their direct-current distribution system requires a ground as a complete or partial circuit return. (page 5-12, para 5-3e)

10. C. The current leaves the pipe through the soil to the cinders and returns to the pipe. Severe corrosion occurs at the points where the current leaves the pipe. (page 5-12, para 5-3b)

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APPENDIX A

LIST OF COMMON ACRONYMS

ACCP	Army Correspondence Course Program
ACGIH	American Conference of Government Industrial Hygienists
AFI	Air Force instruction
AFJI	Air Force joint instruction
AFM	Air Force manual
AFP	Air Force pamphlet
AIPD	Ar-my Institute for Professional Development
AISI	American Iron and Steel Institute
AMEDD	Army Medical Department
ANA	Air Force Navy Aeronautical
APO	Army Post Office
attn	attention
AV	Automatic voice network
AWR	answer weight refrernce
CAS	chemical abstract service
CFR	code of federal regulations
CNS	central nervous system
CO_2	carbon dioxide
CPSC	Consumer Product Safety Commission
DETC	Distance Education and Training Council
DIBK	di-isobutylene ketone
DINFOS	Defense Information School

DOD	Department of Defense
DPW	Department of Public Works
DSN	Defense Switching Network
ed	edition
EM	engineer manual
EN	engineer
EPA	Environmental Protection Agency
F	Fahrenheit
FM	field manual
Hg	mercury
HMIS	hazardous materials information system
H_2O	dihydrogen oxide
IARC	International Agency for Research on Cancer
ICE	Interservice Correspondence Exchange
IMP	interior marble polished
IPD	Institute for Professional Development
Jan	January
JFK	John Fitzgerald Kennedy
kg	kilogram(s)
LBPPA	Lead-Based Paint Prevention Act
LEL	lower explosion level
MEK	methyl ethyl ketone
MI	middle initial
MIBK	methyl isobutyl ketone

MIL-STD	military standard
ml	milliliter(s)
mm	millimeter(s)
MO	Missouri
MOS	military occupational specialty
MSDS	material safety data sheet
NA	not applicable
NAVAFAC MO	naval facilities maintenance order
NFPA	National Fire-Prevention Association
NTP	normal temperature and pressure
OPNAVINST	Office of the Chief of Naval Operation Instruction
OSHA	Occupational Safety and Health Administration
para	paragraph
PEL	permissible exposure limit
ppm	parts per million
RCOAC	Reserve Officer Advanced Course
reg	regulation
RS	resource
RYE	retirement year ending
SAE	Society of Automotive Engineers
Sept	September
SARA	Superfund Amendments and Reauthorization Act
SM	soldier's manual
SSN	social security number

SP	surface preparation
TB MED	technical bulletin medicine
TLV	threshold-limit value
TM	technical manual
™	trade mark
TO	technical order
TRADOC	United States Army Training and Doctrine Command
UEL	upper explosion level
US	United States (of America)
V	volt
VA	Virginia
VOC	volative organic compound
vol	volume
WI	Wisconsin

APPENDIX B

RECOMMENDED READING LIST

The following publications provide additional information about the material in this subcourse. You do not need these materials to complete this subcourse.

AFI 48-101. *Respiratory Protection Devices.* December 1993.
AFJI 48-107. *Precautionary Measures for Handling Solvents.* August 1997
AFP 127-1 Vol 1. *U.S. Air Force Guide to Mishap Investigation.* 7 March 1987.
AFP 127-1 Vol 3. *Safety Investigation Work Book.* 15 July 1987.
EM 385-1-1. *Safety and Health Requirements Manual.* October 1992.
EM 1110-2-3400. *Painting: New Construction and Maintenance.* 30 April 1995.
FM 5-125. *Rigging Techniques, Procedures, and Applications.* 3 October 1995.
MIL-STD 1212. *Industrial Safety Belts, Straps and Related Equipment. Revision A.* 21 December 1988.
OPNAVINST 5100.23D. *Navy Occupational Safety and Health Program Manual.* 11 October 1994.
TO 00-25-113 series.
TO 00-25-232. *Control and Use of Installation of High Voltage Application.* 28 September 1997.
TB MED 502. *Occupational and Environmental Health Respiratory Protection Program.* 15 February 1982.
TM 5-618. *Paints and Protective Coatings.* NAVFAC M0-110; AFM 85-3. 15 June 1981.
TM 5-800 series.

Nonmilitary Publication

NFPA 101. *Life Safety Code.* 1994.

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APPENDIX C

CONVERSION FACTORS

Multiply	By	To Obtain
Cubic feet	0.02832	Cubic meters
Fahrenheit	-32 5/9	Celsius
Feet	0.3048	Meters
Gallons	3.785	Liters
Horsepower	745.7	Watts
Kilograms	2.2046	Pounds
Inches	2.540	Centimeters
Inches	1,000	Mils
Milliliters	102^3	Liters
Millimeters	0.03937	Inches
Ounces	28.35	Grams
Pints	0.4732	Liters
Pounds	453.6	Grams
Pounds per square inch	703.1	Kilograms per square meter
Quarts	0.9463	Liters

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APPENDIX D

PAINT AND CLEANING SOLVENTS

Solvent	[1]Relative Evaporation Time	[2]Flash Point (°F)	[3]Explosive Limits (Percent by Volume) (Minimum)	(Maximum)	[4]TLV (ppm)
Acetone	4	10	2.6	12.8	1000
Amyl acetate	50	100	1.1	7.5	100
Amyl alcohol	100	115	1.2	10.0	100
Benzene (benzol)	8	10	1.4	7.1	10[5]
Butyl acetate	30	90	1.7	7.6	150
Butyl alcohol (butanol)	70	105	1.4	11.2	50
Carbon tetrachloride[5]	8	Not flammable			10
Diacetone alcohol	200	145	1.8	6.9	30
Di-isobutylene ketone (DIBK)	150	140	0.8	6.2	25
Ethyl acetate	8	40	2.5	9.0	400
Ethyl (grain) alcohol (ethanol)	20	60	4.3	19.0	1000
Ethylene glycol monoethyl ether	100	110	2.6	15.7	200
Ethylene glycol monoethyl ether acetate	32	130	1.7	No data	25
High-flash naphtha (aromatic)	105	105	1.0	7.0	500
Isopropryl acetate	10	50	1.8	7.8	250
Isopropyl alcohol (isopropanol)	25	65	2.5	12.0	400
Methyl (wood) alcohol (methanol)[6]	10	55	5.5	36.5	200[2]
Methylene chloride	4	Not flammable			200
MEK	8	30	1.8	10.0	200
Methyl isobutyl ketone (MIBK)	20	65	1.4	7.5	100
Mineral spirits (petroleum thinner)	150	105	0.8	7.0	NA
Refined kerosene	800	150	0.7	5.0	NA
Toluene (toluol)	15	45	1.3	7.0	100
Turpentine	100	105	0.8	No data	100
Naphtha (benzine)	20	50	1.1	5.9	300
Water	100	Not flammable			NA
Xylene (xylol)	35	85	1.0	6.0	100

PAINT AND CLEANING SOLVENTS (continued)

[1] Relative evaporation time. The relative time required for the solvent to completely evaporate based on an arbitrary value of 1.0 for ethyl ether. The higher the number, the longer the time required for evaporation.

[2] Flash point. The temperature of the solvent in °F at which it releases sufficient vapor to ignite in the presence of a flame. The higher the value, the safer the solvent with respect to the flash point.

[3] Explosive limits. There is a minimum concentration of solvent vapor in the air below which it will not ignite or explode; likewise, a maximum concentration above which it also will not ignite. These are also called flammable limits.

[4] TLV. This is a measure of the concentration of a solvent vapor in the air which can be tolerated during an 8-hour working day. Since these concentrations are very low, they are expressed as parts per million (ppm) of vapor per volume of air. The higher the value, the safer the solvent.

[5] Not approved

[6] Deadly

APPENDIX E

MATERIAL SAFETY DATA SHEET

Regulations determine what information each MSDS must contain; however, the product supplier may determine the reporting format, such as the MSDS in sample A (Figure E-1, pages E-2 and E-3). OSHA prepared an optional MSDS form for suppliers to use, and it is shown in Sample B (Figure E-2, pages E-4 through E-6).

Review the MSDSs to determine what control measures are necessary to prevent health hazards and/or side effects from product ingredients. Select the proper protective clothing, avoid unnecessary or prolonged skin contact, provide adequate ventilation, and use appropriate respiratory measures.

MATERIAL SAFETY DATA SHEET

TRADE NAME 910 Interior Marble, Polished (IMP)	SECTION I	DATE 1 June 1996
MANUFACTURER'S NAME: Di Technologies	EMERGENCY PHONE NUMBER: (414) 555-0058 TRANSPORTATION EMERGENCY: Chemtrec 1-800-555-9300	
ADDRESS: 7070 South 6th Street, Oak River, WI 55555		
NAME OF PERSON TO BE CONTACTED:	FORMULA: Proprietary	

SECTION II INGREDIENTS

CHEMICALS	CAS NUMBER	PERCENT (APPROXIMATE)	TLV (units)
Sodium phosphate		5	NA
Sodium silicate		5	NA

SAMPLE

SECTION III PHYSICAL DATA

BOILING POINT (°F)	212°F	SPECIFIC GRAVITY (H_2O = 1)	1.02
VAPOR PRESSURE (mm Hg)	Lower	PERCENT VOLATILE BY VOLUME	NA
VAPOR DENSITY (AIR = 1)	Lower	EVAPORATION RATE	NA
SOLUBILITY IN WATER	Good	(BUTYL ACETATE = 1)	NA
APPEARANCE AND ODOR	Blue		

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED)	FLAMMABLE LIMITS	LEL	UEL
None	NA	NA	NA

EXTINGUISHING MEDIA
Water

SPECIAL FIRE-FIGHTING PROCEDURE
Use water.

UNUSUAL FIRE AND EXPLOSION HAZARDS
Not present

Figure E-1. Sample A MSDS

SECTION V HEALTH HAZARD DATA

TLV Not established

HMIS RATINGS	HEALTH	2	FLAMMABILITY	0	REACTIVITY	0	PERSONAL PROTECTION	2
NFPA RATINGS	HEALTH	2	FLAMMABILITY	0	REACTIVITY	0	UNUSUAL HAZARDS	2

EFFECT OF OVEREXPOSURE: Skin irritation

EMERGENCY AND FIRST-AID PROCEDURE: IN CASE OF SKIN CONTACT:
Rinse off with water.

IN CASE OF EYE CONTACT:
Flush with plenty of water, and see a physician.

IF SWALLOWED:
Give orange juice, and see a physician.

IF INHALED:
Remove to fresh, ventilated areas.

SECTION VI REACTIVE DATA

STABILITY	UNSTABLE		CONDITIONS TO AVOID:
	STABLE	X	Do not mix with other chemicals.

INCOMPATIBILITY (MATERIALS TO AVOID):
Oxidizing chemicals, such as acids

HAZARDOUS DECOMPOSITION PROCEDURES:
None

HAZARDOUS	MAY OCCUR		CONDITIONS TO AVOID:
POLYMERIZATION	WILL NOT OCCUR	X	Oxidizing chemicals, such as acids

SECTION VII SPILL OR LEAK PROCEDURE

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED:
Wear appropriate protective clothing, chemical eye goggles, gear, and so on.

SMALL SPILL:
Rinse off with water.

LARGE SPILL:
Contain the spill, and place the substance in a suitable container for disposal.

WASTE DISPOSAL METHOD:
Follow all federal, state, and local government regulations.

SECTION VIII SPECIAL PROTECTION INFORMATION

RESPIRATION PROTECTION (SPECIFY TYPE):
Not required

VENTILATION	LOCAL EXHAUST	X	
	MECHANICAL (GENERAL)	X	

PROTECTIVE GLOVES: Rubber gloves	EYE PROTECTION: Chemical eye goggles

OTHER PROTECTIVE EQUIPMENT:
Eye-wash station, work clothes, and rubber boots

SECTION IX SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:
Store at room temperature. Avoid all skin and eye contact. Keep the container closed when it is not in use.

OTHER PRECAUTIONS:
Keep out of reach of children.

Figure E-1. Sample A MSDS (continued)

Material Safety Data Sheet May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Standard must be consulted for specific requirements.	**U.S. Department of Labor** Occupational Safety and Health Administration (Nonmandatory Form) Form Approved Number 1218-0072
IDENTITY (As Used on Label and List) 100-248 SP Black, external, camouflage, latex-based, flat	Note: Blank spaces are not permitted. If any item is not applicable or no information is available, the space must be marked to indicate that.

Section I

Manufacturer's Name Painters, Incorporated	Emergency Telephone Number (314) 555-0318
Address (Number, Street, City, State, and Zip Code) 16600 Trenton	Telephone Number for Information (314) 555-6000
St. Louis, Missouri 63132	Date Prepared 5 July, 1989
	Signature of Preparer (optional)

Section II—Hazardous Ingredients/Identify Information

Hazardous components (specific chemical identity: Common name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	0/0 (optional)
CAS Number 107-21-1 Ethylene glycol		50		

Section III—Physical/Chemical Characteristics

Boiling Point	387°F	Specific Gravity (H_2O = 1)	1.1155
Vapor Pressure (mm Hg)	0.05	Melting Point	NA
Vapor Density (AIR = 1)	2.2	Evaporation Rate (Butyl acetate = 1)	Nil

Solubility in Water
Complete

Appearance and Odor
Clear, colorless, mobile, syrupy liquid with faint odor

Section IV—Fire- and Explosive-Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
Tag-closed cup 232°F		3.2%	15.3%

Extinguishing Media
(1) Dry chemical, (2) CO_2, and (3) Foam

Special Fire-Fighting Procedures
A straight stream of water will spread the fire.

Unusual Fire and Explosion Hazards A vapor accumulation will flash and/or explode if ignited. Containers may burst explosively if overheated in fire. Cool with water, spray, or foam. Empty containers also present a fire and explosive hazard due to residual vapors.

(Reproduce locally) OSHA 174, Sept. 1985

Figure E-2. Sample B MSDS

Section V—Reactivity Data			
Stability	Unstable		Conditions to avoid
	Stable	X	Heat, sparks, and open flame
Incompatibility (Materials to Avoid) Strong-oxidizing agents			
Hazardous Decomposition or Byproducts NA			
Hazardous Polymerization	May occur		Conditions to avoid
	Will not occur	X	NA
Section V—Health-Hazard Data			
Route(s) of Entry:	Inhalation? X	Skin? X	Ingestion? X
Health Hazards (Acute and Chronic) Inhalation: Vapors may be irritating to nose, throat, and respiratory tract. High vapor concentration may cause central nervous system (CNS) depression.			
Skin: Liquid is slightly irritating to the skin. Prolonged or repeated contact can result in defatting and frying of the skin, which may result in skin irritation and dermatosis.			
Ingestion: Ingestion of product may result in vomiting. Aspiration (breathing) of vomitus into the lungs must be avoided as even small quantities may result in aspiration pneumonitis.			
Carcinogenicity: NA	NTP? NA	IARC Monographs? NA	OSHA Regulated? NA
Signs and Symptoms of Exposure Irritation as noted above. Early to moderate CNS. Depression may be evidenced by giddiness, headache, dizziness, and nausea. In extreme cases, unconsciousness or death may occur. Aspiration pneumonitis may be evidenced by coughing, labored breathing, and cyanosis (bluish skin). In severe cases, death may occur.			
Medical Conditions Generally Aggravated by Exposure Preexisting eye, skin, and respiratory disorders may be aggravated by exposure to this product.			
Emergency and First-Aid Procedures Please see attached.			
Section VII—Precautions for Safe Handling and Use			
Steps to be Taken in Case Material Is Released or Spilled Remove all sources of ignition. Provide adequate ventilation. Avoid breathing vapors. Shut off source of spill if it can be done safely. Use nonsparking tools. Absorb on absorbant material.			
Waste Disposal Method Incinerate in accordance with pollution-control regulations, or use other methods for disposal which are in compliance with federal, state, and local regulations.			
Precautions to be Taken in Handling and Storing Store in original, tightly closed container in a cool, dry place that is away from all sources of ignition.			
Other Precautions NA			
Section VIII—Control Measures			
Respiratory Protection (Specify Type) Use air-supplied or self-contained breathing apparatus in areas of high vapor concentrations.			
Ventilation Explosion-proofed	Local Exhaust As required to keep vapor concentrations below the TLV (see Section II).		Special NA
	Mechanical (General) NA		Other NA
Protective Gloves Recommended		Eye Protection Chemical and/or vapor-proof safety goggles	
Other Protective Clothing or Equipment As required to avoid wetting clothing and skin			
Work/Hygienic Practices Avoid contact where possible.			

Figure E-2. Sample B MSDS (continued)

PAINTERS, INCORPORATED

16600 TRENTON
ST LOUIS, MISSOURI 63132
(314) 555-6000

MATERIAL SAFETY DATA SHEET ADDENDUM
SARA TITLE III
SECTION 313 SUPPLIER NOTIFICATION

The purpose of this MSDS addendum is to identify ingredients in this product that are toxic chemicals and are subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and of 40 CFR 372. We, as a supplier, are required to report this information to you on an annual basis with your first order of each product for each year.

Provided in Section II—Hazardous Ingredients of this MSDS are the hazardous ingredients in this product, identified by name, and percent by weight. Listed below, in order of CAS number, are raw materials in all of our products that are designated by Section 313 as toxic chemicals.

In order to identify the toxic chemicals in this product, please refer to each ingredient in Section II of the MSDS. If a match occurs between an ingredient in Section II of the MSDS and a material on the list, that ingredient is a Section 313 reportable toxic chemical.

NOTE: This addendum is an integral part of this product MSDS and must remain attached. This addendum must be included in any copying or redistribution of this MSDS.

CAS NUMBER	CHEMICAL NAME	CONCENTRATION
7429-90-5	Aluminum (fume or dust)	1.0
7440-47-3	Chromium	0.1
7440-48-4	Cobalt	1.0
107-21-1	Ethylene glycol	1.0
7439-96-5	Manganese	1.0
78-93-3	MEK	1.0
108-10-1	MIBK	1.0
85-44-9	Phthalic anhydride	1.0
108-05-4	Vinyl acetate	1.0
1330-20-7	Xylene (mixed isomers)	1.0

Emergency and First-Aid Procedures

Skin contact: Remove contaminated clothing/shoes. Flush skin with water. Follow by washing with soap and water. If irritation occurs, get medical attention. Do not reuse clothing until cleaned.

Inhalation: Remove victim to fresh air and provide oxygen if breathing is difficult. Give artificial respiration if not breathing. Get medical attention.

Ingestion: Do not induce vomiting. If vomiting occurs spontaneously, keep head below hips to prevent aspiration of liquid into lungs. Get medical attention.*

Note to physician:
*If more than 2.0 ml per kg has been ingested and vomiting has not occurred, emesis should be induced with supervision. Keep victim's head below hips to prevent aspiration. If symptoms such as loss of gas reflex, convulsions, or unconsciousness occur before emesis, gastric lavage using a cuffed, endotracheal tube should be considered.

Figure E-2. Sample B MSDS (continued)

*U.S. Government Printing Office: 2000 — 528-075/20340